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INTRODUCTION.

As explained in this Introduction during 1914, the MONTHLY WEATHER REVIEW now takes the place of the Bulletin of the Mount Weather Observatory and of the voluminous publication of the climatological service of the Weather Bureau. The MONTHLY WEATHER REVIEW contains contributions from the research staff of the Weather Bureau and also special contributions of a general character in any branch of meteorology and climatology.

SUPPLEMENTS to the MONTHLY WEATHER REVIEW will be published from time to time.

The climatological service of the Weather Bureau is maintained in all its essential features, but its publications, so far as they relate to purely local conditions, are incorporated in the monthly reports "Climatological Data" for the respective States, Territories, and colonies.

Since December, 1914, the material for the MONTHLY WEATHER REVIEW has been prepared and classified in accordance with the following sections:

SECTION 1.—*Aerology*.—Data and discussions relative to the free atmosphere.

SECTION 2.—*General meteorology*.—Special contributions by any competent student bearing on any branch of meteorology and climatology, theoretical or otherwise.

SECTION 3.—*Forecasts and general conditions of the atmosphere*.

SECTION 4.—*Rivers and floods*.

SECTION 5.—*Seismology*.—Results of observations by Weather Bureau observers and others as reported to the Washington office. Occasional original papers by prominent students of seismological phenomena.

SECTION 6.—*Bibliography*.—Recent additions to the Weather Bureau library; recent papers bearing on meteorology.

SECTION 7.—*Weather of the month*.—Summary of local weather conditions; climatological data from regular Weather Bureau stations; tables of accumulated and excessive precipitation, data furnished by the Canadian Meteorological Service; monthly charts Nos. 1, 2, 3, 4, 5, 6, 7, 8, the same as hitherto.

In general, appropriate officials prepare the seven sections above enumerated; but all students of atmospherics are cordially invited to contribute such additional articles as seem to be of value.

The voluminous tables of data and text relative to local climatological conditions that during recent years were prepared by the 12 respective "district editors," are omitted from the MONTHLY WEATHER REVIEW, but collected as "Climatological Data" and published by States at selected section centers.

The data needed in Section 7 can only be collected and prepared several weeks after the close of the month whose name appears on the title page; hence the REVIEW as a whole can only issue from the press within about eight weeks from the end of that month.

It is hoped that the meteorological data hitherto contributed by numerous independent services will continue as in the past. Our thanks are specially due to the directors and superintendents of the following:

The Meteorological Service of the Dominion of Canada.
The Meteorological Service of Cuba.
The Meteorological Observatory of Belen College, Habana.
The Government Meteorological Office of Jamaica.
The Meteorological Service of the Azores.
The Meteorological Office, London.
The Danish Meteorological Institute.
The Physical Central Observatory, Petrograd.
The Philippine Weather Bureau.

SECTION I.—AEROLOGY.

SOLAR AND SKY RADIATION MEASURED AT WASHINGTON, D. C., DURING MAY, 1915.

By HERBERT H. KIMBALL, Professor of Meteorology.

[Dated: Washington, D. C., June 10, 1915.]

In Table 1 are summarized the measurements of the intensity of direct solar radiation made by the Weather Bureau at the American University[1] during May 1915. A Marvin pyrheliometer was employed in making measurements. The sky was generally unfavorable for this work, as the occasions were rare when some clouds were not present. However, a measurement of 1.45 calories per minute per square centimeter of normal surface, obtained shortly after noon of the 27th, is the highest ever obtained at Washington in the month of May. On other days the intensities were generally below the average for May.

Sky-light polarization, measured at a point 90° from the sun and in his vertical, with the sun at zenith distance 60°, averaged 50 per cent, with a maximum of 53 per cent, which is 4 per cent below the average maximum for May.

In Table 2, column 2 gives the daily totals of solar and sky radiation received on a horizontal surface at the American University. The measurements were made with a Callendar recording pyrheliometer in the manner described in this REVIEW for March, 1915, **43**:100. Column 3 of Table 2 gives the departures of these daily totals from the daily normals published in the same number of the REVIEW, p. 108, Table 4.

TABLE 1.—*Solar radiation intensities at Washington, D. C., during May, 1915.*

[Gram-calories per minute per square centimeter of normal surface.]

Date.	Sun's zenith distance. 0.0°	48.3°	60.0°	66.5°	70.7°	73.6°	75.7°	77.4°	78.7°	79.8°	80.7°
	Air mass. 1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
1915 A. M.	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*
May 1	1.20	1.02	......	......	......	......	......	......	......	......	......
2	......	1.22	1.07	0.96	......	......	......	......	......	......	......
6	......	1.15	1.03	0.93	0.85	0.78	0.70	0.65	0.59	0.54	0.50
9	......	1.19	1.06	......	......	......	......	......	......	......	......
10	......	......	1.04	0.83	0.64	0.59	......	......	......	......	......
15	......	......	......	0.70	......	......	......	......	......	......	......
18	......	1.18	1.04	0.92	......	......	......	......	......	......	......
23	......	1.17	......	......	......	......	......	......	......	......	......
24	......	1.21	1.12	......	......	......	......	......	......	......	......
27	1.46	1.36	1.27	1.18	1.09	1.03	0.99	......	......	......	......
31	......	1.27	......	......	......	......	......	......	......	......	......
Means	**(1.33)**	**1.20**	**1.09**	**0.92**	**0.86**	**0.80**	**(0.64)**	**(0.65)**	**(0.59)**	**(0.54)**	**(0.50)**
P. M. May 4	1.33	......	......	......	......	......	......	......	......	......	......
10	......	1.17	1.02	0.87	0.78	0.69	0.60	0.52	......	......	......
27	1.46	1.33	1.25	1.17	1.10	1.02	0.96	0.89	0.81	......	......
Means	**(1.40)**	**(1.25)**	**(1.14)**	**(1.02)**	**(0.99)**	**(0.86)**	**(0.78)**	**(0.70)**	**(0.81)**	......	......

The "Percentage of possible sunshine," and the "Average cloudiness," given in columns 5 and 6 of Table 2, have been taken from the records of the observatory at the central office of the Weather Bureau.

The above data show more than the average cloudiness, less than the average sunshine, and solar radiation below the average intensity for the month, during May, 1915, and especially during the last two decades.

TABLE 2.—*Daily totals and departures of solar and sky radiation at Washington, D. C., during May, 1915.*

[Gram-calories per square centimeter of horizontal surface.]

Date.	Daily total.	Departure from normal.	Excess or deficiency since first of month.	Percentage of possible sunshine.	Average cloudiness.
	Gr.-cal.	*Gr.-cal.*	*Gr.-cal.*	*Per cent.*	*0-10*
May 1	458	−36	−36	46	7
2	507	8	−28	82	4
3	433	−71	−99	43	6
4	375	−134	−233	34	7
5	436	−78	−311	71	6
6	578	60	−251	98	3
7	319	−201	−452	24	10
8	388	−134	−586	44	9
9	636	112	−474	100	1
10	564	38	−436	93	3
11	520	−7	−443	93	6
12	71	−458	−901	0	10
13	533	3	−898	66	5
14	595	64	−834	77	2
15	526	−6	−840	92	6
16	251	−281	−1,121	6	8
17	273	−259	−1,380	25	8
18	457	−75	−1,455	53	6
19	606	74	−1,381	93	5
20	183	−349	−1,730	0	10
Decade departure	....	....	**−1,294**	....	....
21	355	−177	−1,907	37	8
22	432	−100	−2,007	61	7
23	627	95	−1,912	99	4
24	340	−192	−2,104	25	9
25	648	116	−1,988	79	3
26	343	−188	−2,176	14	9
27	757	226	−1,950	100	0
28	508	−23	−1,973	37	7
29	99	−431	−2,404	0	10
30	206	−324	−2,728	0	10
31	677	147	−2,581	90	3
Decade departure	....	....	**−851**	....	....
Total deficiency since first of year	....	....	**−1,672**	....	....

CONFIRMATORY EXPERIMENTS ON THE VALUE OF THE SOLAR CONSTANT OF RADIATION.[1]

By C. G. ABBOT, F. E. FOWLE, and L. B. ALDRICH.

[Presented to the National Academy of Sciences, Apr. 27, 1915.]

We have made hitherto nearly 1,000 determinations of the intensity of solar radiation outside the atmosphere at mean solar distance, termed the solar constant of radiation. The mean value found is 1.93 calories per square centimeter per minute. Langley's spectro-bolometric method was employed. This consists in determining the distribution of the energy in the solar spectrum at different solar zenith distances, and thereby computing coefficients of atmospheric transmission suitable to determine the energy curve outside the atmosphere. The bolometric measurements are reduced, in terms of standard 15° calories per square centimeter per minute, by the aid of comparisons made each day of observation with stand-

[1] For a description of instrumental exposures and methods of observation see this REVIEW, December, 1914, **42**: 648.

[1] *Reprinted from* Proceedings, National Academy of Sciences, Washington, June 15, 1915, **1**: 331-333.

ardized pyrheliometers. Observations have been made at Washington (sea level); Bassour, Algeria (1,160 meters); Mount Wilson, Cal. (1,730 meters); and Mount Whitney, Cal. (4,420 meters). They have continued during all the years 1903 to 1914. Great changes from day to day and from place to place in temperature, in barometric pressure, in humidity, in haziness, while of course greatly affecting measurements of intensity at the stations and of atmospheric transparency computed, nevertheless have not produced differences of the solar constant values. This seems to us to be strong evidence of the soundness of the method.

In the second place, it has been shown by Fowle that the atmospheric transmission coefficients obtained at Mount Wilson fit well with Lord Rayleigh's theory of atmospheric scattering, except for those regions of spectrum where numerous atmospheric lines and bands of true absorption are known to occur. Fowle has computed from the transmission coefficients that the number of molecules per cubic centimeter of air at standard temperature and pressure is $(2.70 \pm 0.02) \times 10^{19}$. This value is very close to Millikan's determination by absolutely independent observations and methods, namely $(2.705 \pm 0.005) \times 10^{19}$.

In the third place, simultaneous solar-constant observations at Mount Wilson and Bassour, separated by one-third the earth's circumference, unite in showing a substantial irregular variability of the sun from day to day. This solar variability has been of late independently confirmed by us by examination of the distribution of brightness along the diameter of the sun's disk. The latter observations show variations of distribution from day to day, and these accompany pretty closely the variations of the total solar radiation. It seems to us that, as the fact of solar variability is thus independently confirmed as a real phenomenon, it speaks favorably for the substantial accuracy of our solar-constant measurements that it was through them that the irregular variations of from 1 to 5 or, very rarely, 10 per cent were first discovered.

Notwithstanding these evidences of the soundness of our solar constant work, various attacks upon it have been made, tending to show that the solar constant is much higher than 1.93 calories, perhaps even 3.5 to 4.0 calories. A principal argument is that the atmospheric transparency continually diminishes as the sun rises within 75° zenith distance, so that our values of atmospheric transmission are much too great and have no relation to the transmission of an atmosphere of constant transparency. Secondly, it is said that measurements of solar radiation exceeding 1.93 calories have been made on mountain tops and from free balloons. Various other objections are raised, which we discuss in our paper now being published by the Smithsonian Institution.[2]

On two days, September 20 and 21, 1914, we continued solar-constant observations at Mount Wilson from the instant of sunrise until about 10 o'clock. We have reduced the work by the aid of Bemporad's air-mass formulæ and tables. As these postulated uniform optical quality of the atmosphere from bottom to top, it was necessary to apply certain corrections to them varying with the wave-length, depending upon the extinction by water vapor residing in the lowest atmospheric strata. We were enabled to determine these corrections by Fowle's studies of the effects of water vapor. We find on both days that the atmospheric transparency remained sensibly unaltered from sunrise to 10 o'clock. Closely identical values of the solar constant are obtained, whatever the range of air masses used to determine the atmospheric transmission. We made three independent estimates for each day, for air-mass ranges 1.3 to 4; 4 to 12; and 1.3 to 20, respectively. All six solar-constant values thus found fall between 1.90 and 1.95 calories. The smallest air masses, as it happens, yield slightly the highest values. We conclude that our previous results have not been made too small by neglecting to observe during the time when the sun is within 15° of the horizon.

[2] **Abbott, C. G.,** *and others.* New evidence on the intensity of solar radiation outside the atmosphere. Washington, 1915. p. l., 55 p. 8°. (Smithsonian misc. coll., v. 65, no. 4. Publ. 2361.)

On July 11, 1914, in cooperation with the United States Weather Bureau, a recording pyrheliometer attached to sounding balloons was sent up to the altitude of about 24 km., where the barometric pressure was 3 cm. of mercury, which is only one twenty-fifth of that prevailing at sea level.

Good records of solar radiation were obtained over a period of more than an hour and including the period when the instrument reached its highest elevation. The mean value of the best three records made at highest altitudes, as reduced to mean solar distance, comes out 1.84 calories per square centimeter per minute. We believe that about 2 per cent should be added to represent radiation scattered and absorbed in the atmosphere above the level reached, making the probable value of the solar constant, from this day's work, 1.88 calories. This value falls decidedly within the range of solar constant values we have observed. We state in connection with it the following results, which are the highest reliable direct observations of solar radiation at the various altitudes, as reduced to mean solar distance and vertical sun:

TABLE 1.—*The highest reliable direct observations of solar radiation at the various altitudes.*

[Reduced to mean solar distance and vertical sun.]

Station.	Washington.	Mount Wilson.	Mount Whitney.	Manned balloon.	Free balloon.
Altitude	127 m	1,730 m	4,420 m.*	7,500 m	24,000 m.
Barometer	75 cm	62 cm	45 cm	30 cm	3 cm.
Radiation	**1.58 cal**	**1.64**	**1.72**	**1.755**	**1.84 cal.**
Observer	Kimball	Abbot	Abbot	A. Peppler	(Smithsonian.)

SOLAR HALO OF MAY 11, 1915, AT SAND KEY, FLA.

By CLARENCE G. ANDRUS, Assistant Observer.

[Dated: Weather Bureau, Sand Key, Fla., May 11, 1915.]

On the afternoon of May 11, 1915, there was observed at Sand Key, Fla. ($\varphi = 24° 27'$ N.; $\lambda = 81° 53'$ W.), a rather unusual display of prismatic arcs in the heavens. The phenomena were observed and noted with the strictest accuracy possible under the circumstances, but it is regretted that no instrumental measurements and no photographs of the halos could be secured. The somewhat crude observing methods practicable were carefully carried out and the author feels certain that errors were nearly eliminated. All records are in 90th meridian time. The observations were made by the writer, and Mr. H. L. Riley carefully checked and confirmed the data.

The cloud forms causing the phenomena were of the cirro-stratus type and were moving toward the east. Throughout the afternoon the sky was about 5/10 covered, the cirro-stratus being arranged as a broad band from east to west. The edge to the southward was well defined and appeared as an upwardly curling front on which no halo-form curves were seen. In structure the clouds were not of pallium form but were filamentary and might well be described as resembling the warp and woof threads in a threadbare cloth.

The first suggestion of a halo was manifest at 2:20 p. m. when a short arc of 22° radius appeared between the zenith and the sun. Five minutes later, while viewing the developing halo, I became faintly aware of other curves within the ordinary halo. All doubts were removed at 2:35 p. m., when the inner curves assumed faint but definite colors and the arcs increased in length. I immediately measured them and sketched an outline of the general features. This sketch corresponded with the sketch made later (at 3:00 p. m.; see fig. 1), except that the curve at 28°–29° was not yet visible. As a check, the ordinary halo was measured; the result was 22° 50′, a trifle too large. The radii of the inner ones were not established at this time. During the next 15 minutes the distinctness of the whole phenomenon fluctuated to a considerable extent and at times portions became nearly lost to the eye. At this time glimpses were had of a colored curve lying outside of the 22° arc. This curve was clearly seen later. (Fig. 1, a_1.)

a, halo of 22°; a_1, halo of 28°–29°; *a′*, halo of 18°–19°; *a″*, halo of 17°–18°; *a‴*, halo of 8°–9°

FIG. 1.—Sketch of halos of abnormal radius observed at Sand Key, Fla., on May 11, 1915, at 3:00 p. m., 90th merid. time, by C. G. Andrus, Assistant Observer, Weather Bureau. The brightness varied inversely as the depth of the shading.

Conditions became exceptionally favorable at 3 p. m. The entire spectacle was then at its best. Then it was that the five concentric curves were clearly visible simultaneously. The unusual radius was more striking in each case than was the brightness or attractiveness of the display. The 8°–9° arc could not be definitely seen beside the unshaded sun, and but for the fact that its red color was on its inner circumference, it might have been mistaken for a corona of large radius. A sketch, drawn from the rough original, of the aspect of the phenomena at 3:00 p. m. is reproduced in figure 1. This sketch, however, fails to indicate that the two arcs of about 18° radius do not merge but are separated by a space of about ½ degree in width.

The angular measurements of the radii of the halos were made with the aid of three pins, A, B, and C, stuck in a pad of paper. Pins A and C were thrust in permanently and in such a way that when A is nearer the sun the pin's shadow is quite long and always falls upon C or on the line connecting C and A. While keeping A thus accurately pointed toward the sun, the observer having his eye at C, the third pin, B, is inserted so that it is in line with the halo to be measured and with the eye at C. Thus is obtained a graphic representation of the angle ACB (sun–eye–halo) which is resolved by the use of right triangles and the trigonometric ratios. This method was used for the measurement of all but the innermost and outermost arcs. The innermost one was too near the dazzling sun and the outermost was fast fading when its measure was about to be taken. This latter one was estimated to have a radius about one and one-third times that of the 22° halo.

At 3:09 p. m. all arcs but the 22°-halo had faded; but a careful watch was kept and at 4:25 p. m. a sun-dog began to brighten to the left of the sun and at his altitude, on the outer edge of the 22° halo. At 4:30 p. m. the arc of the circumzenithal circle was observed and measurements and a sketch were at once made (4:33 p. m.). The sun's altitude was gaged to be slightly less than 18° and the solar distance to the nearest portion of the circumzenithal arc as slightly less than 45°. At 4:52 p. m. the distance of the arc from the sun was measured as 53°. There is a possibility that this is slightly too large, but the error should not be more than 1½°. The arc had faded at 5:00 p. m., but the parhelion remained until 5:05 p. m., and the halo continued visible until shortly before sunset.

In regard to the arrangement of the colors of the arcs, it was especially noted that in the case of all five halo-curves, the parhelion, and the circumzenithal arc, the red of the spectrum was on the side nearer the sun. Thus, in the halo-curves and the parhelion the red was on the inner circumference, but in the circumzenithal arc the red was on the outer circumference of the curve.

SOLAR HALO OF MAY 20, 1915, AT PHILADELPHIA.

On May 20, 1915, there was a brilliant solar halo visible from about 10 a. m. (75th meridian time) to after noon, at many points in Pennsylvania, Delaware, New Jersey, New York, and Connecticut. This area of visibility corresponded very closely to the area covered by a lunar halo on April 26, 1898, described in this REVIEW, April, 1898, **26**: 168. The phenomenon of the present month caused widespread comment, and quite a little alarm among those ignorant of its true nature and significance; Weather Bureau offices and private observatories were everywhere busy for several hours "answering the questions of the curious and allaying the fears of the superstitious." The nature of many of the questions offers an interesting index of the present unusual mental state of many of our people.

On another page we print Prof. C. S. Hastings's explanation of the halo and interesting features that have been discovered by the aid of photography. George S. Bliss, Section Director in charge of the Weather Bureau station at Philadelphia, sends the following description of the phenomenon as seen at his station:

On May 20, 1915, there was visible at this station, and for some distance around, the most brilliant solar halo I have ever seen. The phenomenon lasted, with little or no change in appearance, from 10 a. m. until 12:30 p. m., when the clouds changed to cirro-cumulus and it disappeared quite abruptly. The inner circle [halo of 22°?] was as bright as any rainbow, while the segment of the outer circle [46°-halo?] was almost as bright, but was limited in extent to an arc of about 60° or 70°. The small secondary circle [parhelic circle] was complete, was very bright, and perfectly white with no yellowish cast.

Toward Zenith.

FIG. 1.—Full-size photograph of the solar halo (Oval of Venturi) seen at New Haven Conn., Thursday, May 20, 1915, at 11:45 a. m. The vertical is to the horizontal diameter, as 1 : 1.07. [Copyright, 1915. Chas. H. York.]

This report by Mr. Bliss was of interest in confirming the presence and the length of the inferior segment of the 46°-halo also reported by Prof. Hastings in his article following. Other reports on these halos may reveal further interesting features, but it is particularly to be regretted that Mr. Bliss did not measure or photograph his phenomenon, for, as pointed out below, it is probable that the supposed 22°-halo was really the circumscribed halo of 22° sometimes called the Oval of Venturi (see this REVIEW, July, 1914, **42**:439 and fig. 10). Our observations still emphasize the great need in this country for more accurate observations and measurements of halos. Mr. Andrus's observations (p. 214) deserve special commendation on this account. Other observations of the halo of May 20 reveal the fact that the anthelion and the oblique arcs of the anthelion were certainly observable at Reading, Pa., and at Atlantic City, N. J.; but as pointed out elsewhere (MONTHLY WEATHER REVIEW, July, 1914, pp. 434–435) the mere observation is of relatively small value, and our reports from those stations do not tell us the angle between the arcs of the anthelion nor their precise angular length.—C. A., jr.

HALO OF MAY 20, 1915, AT NEW HAVEN, CONN.

By Prof. C. S. HASTINGS.

[Dated: Sloane Laboratory, Yale University, May 21, 1915.]

A remarkably vivid solar halo was observed at New Haven, as at many places in the eastern portion of our country, on May 20, 1915. There were some features of peculiar interest which may have been overlooked and which are important as bearing upon the theoretical explanations of phenomena, often of extraordinary complexity, and always of great popular interest. With a view of interesting meteorologists in a theory which has been quite completely worked out and published[1] many years ago, I venture to send you an account of observations made by myself and companions together with certain theoretical conclusions. All significant observations were made between 11:30 a.m. and noon, while the sun was at an altitude of 68° or more.

The most surprising features of the halo at first glance were the extreme liveliness of the colors and the impressive darkness of the space inside the apparent circle, a contrast far surpassing any previous cases observed by us. The ring appeared notably more brilliant above and below than east and west of the sun. A careful search for appendages to the ring was without fruit until my attention was directed to an arc—perhaps 60° in extent—vertically below the sun and bisected by the vertical circle through the sun. This was relatively faint, but of purer colors than those of the smaller ring. There could be no doubt that this was a portion of the well-known 46°-halo and was attributable to refraction by means of crystal faces at right angles to each other, such as are found at the bases of hexagonal ice crystals.

It will be observed that the whole phenomenon was no more surprising for its brightness than for its simplicity, and it is just this latter feature which renders it particularly important from the standpoint of the theorist.

The feature which first impressed itself upon the mind of the writer as an indication that we did not have here the familiar 22°-circle was the relative darkness of the sky within the ring. It was inconceivable that fortuitously arranged crystals of ice could yield so intensely colored a circle with so little diffused light that the sky within its area was a blue sky, far indeed from being milky, which it became a few minutes later. If not explicable by fortuitously arranged crystals it was not the 22°-circle at all, but the "Oval of Venturi," which the upper and lower tangent arcs of the 22°-halo form by uniting when the altitude of the sun is sufficiently great. If this were the true type the horizontal diameter of the ring should be slightly greater than the vertical and the upper and lower portions of the ring should be brighter than the eastern and western portions. The first condition I thought I established by rough measurements immediately after the question as to the nature of the phenomenon entered my mind, while the second condition was manifest to any observer whose attention was directed to it.

Very fortunately there is independent and perfect evidence for the correctness of my conclusions. Mr. Charles N. York, of this city [New Haven, Conn.], had the happy thought of photographing the ring and secured an excellent negative on an 8 by 10 plate.[2] (See fig. 1, opposite.) This shows perfectly that the ring had a horizontal diameter about 7 or 8 per cent greater than the vertical, and that the upper and lower portions were much brighter than the lateral portions, the distribution of light being symmetrical with respect to a vertical circle through the sun. Naturally, the angular extent of field was far too small to show the fragment of the 46°-circle; as a matter of fact the angular value of the plate was only just adequate for taking the whole of the ring. Exactly what instant the exposure was made is unknown to me,[2] but it was after the first moments when my companions and I observed it wholly without cirrus clouds within the ring.

To summarize the observations we may say that this halo was a magnificently developed one of extreme simplicity, having only two elements, namely, the Oval of Venturi and a fragment of the 46°-circle. The theoretical explanation is also simple. We conclude that only a single kind of ice crystals was present, namely, elongated hexagonal prisms with bases at right angles to their axes; that these prisms were falling with their axes horizontal and, in general, rotating about their axes. The ring, or oval, was produced by refraction through two alternate faces of the prism whenever a crystal at about 22° from the sun happened to present itself in a favorable position—that is, whenever the light thus refracted should be deviated by an angle little different from the minimum of 22°.

The fragment of the 46°-circle was due to those crystals which happened to be at this angular distance from the sun and so placed that light from the sun could enter at a basal face—vertical in position—and emerge at a prismatic face which happened to be in such a position that the deviation should be very near the minimum of 46°. The high degree of saturation of the colors is due to the obviously narrow range of possible departure from this minimum. A simple calculation, or geometric construction, shows that for minimum deviation in a 90° angle of ice the light should enter one face at an angle of 22° from it (an "angle of incidence" of 68°) and emerge at the other at the same angle; but this is just the angle at which sunlight would fall on vertical surfaces at the time of the observations, the zenith distance of the sun being very nearly 22° during the whole. Here we have a case

[1] **Hastings, C. S.** Light. Chas. Scribner's Sons, New York, 1901.

[2] The accompanying beautiful large-scale photograph of the solar halo of May 20, 1915, we owe to the enthusiasm and generosity of Charles N. York, of New Haven, Conn. For the benefit of those who may wish to attempt halo-photography in the open, Mr. York sends the following information:

The photograph reproduced here, was made at 11:45 a. m. (75th mer. time), using a Goerz "Dagor" lens of 9½ inches focal length, and stop 32. The plate was an 8 × 10 Stanley "Commercial", exposed behind a "15-time" ray filter for $\frac{1}{10}$ second. A "pyro" developer was used.

in which the existing portion of the 46°-circle was in fact produced by oriented crystals and so far supports the view advocated on page 219 of the work cited above, namely, that this circle is always produced in a similar way and that the accepted explanation by Cavendish, which attributes it to the action of fortuitously directed ice crystals, is quite inadequate. Among my notes of past observations I find those describing a halo seen at this place on February 13, 1914, when a portion of this halo of very unusual distinctness was seen above the sun, whose altitude was 22° 7′. Here we had a case where the refracted light entered a horizontal lateral face of the ice crystal and emerged at a vertical base, with equivalent angles of incidence and emergence.

On May 20, 1915, a certain feature was missing which might be expected in a halo produced by oriented crystals, namely, the parhelic circle—that is, the colorless horizontal circle passing through the sun. This feature is said to be very frequently observed in northern Europe, but, at least as far as the present writer's observations are decisive, is not often seen in this region. In the general theory referred to above, it is argued that, contrary to the accepted views, this circle can only be due to total reflections from the interior of prisms with continuously vertical faces. In the case under discussion we had, at first view, all the necessary conditions, yet not a trace of the parhelic circle could be found. The theoretical difficulty here presented vanishes when subjected to quantitative test. Owing to the great altitude of the sun the projected area of the total reflecting faces was reduced to less than three-tenths their true area even in their most favorable position at an azimuth 180° from the sun; in general it would be much less than this. This is in complete accordance with the fact that I find no record of a parhelic circle with the altitude of the sun within 10 degrees as great as that observed. It would be difficult to account for this limitation as regards altitude unless the total reflection explanation be accepted.

SECTION II.—GENERAL METEOROLOGY.

THE REGION OF GREATEST SNOWFALL IN THE UNITED STATES.

By ANDREW H. PALMER, Assistant Observer.

[Dated: Weather Bureau, San Francisco, Cal., Apr. 13, 1915.]

DEEP SNOWFALLS.

California, usually thought of as a land of fruit, sunshine, and flowers, also has within its borders the region of greatest snowfall in the United States. The apparent anomaly is explained by the fact that this State (second in size in the Union) is an empire in itself. Variety is the keynote in all of its physical features, and extreme variety is noticeable in the climate of its various parts. For example, during the year 1913 a temperature of −21°F. was recorded at Alturas on January 23, while a temperature of +134°F. occurred at Greenland Ranch on July 10. Moreover, during that same year no measurable amount of rain occurred at Bagdad, Cal., while in the northern part of the State 100 inches of precipitation occurred. Twelve regular and 235 cooperative stations of the United States Weather Bureau are now in operation within the State of California. They extend vertically from Mecca, 185 feet below sea level, to Bishop Creek, 8,500 feet above sea level. It is doubtful if any other State can afford a variety of climatological data equal to that recorded at these stations.

Though there may be a greater average seasonal snowfall in some of the uninhabited and unstudied portions of the United States, the records obtained in the high Sierra Nevada of California have not been exceeded. Particularly is this true of the region adjacent to the line of the Southern Pacific Railroad which connects Sacramento, Cal., with Reno, Nev. Throughout many square miles in the Sierras traversed by this line more than 100 inches of unmelted snow falls every winter, making it the region of heaviest known snowfall in the United States. The Snow and Ice Bulletin published weekly by the Weather Bureau throughout the winter does not include data from this region, as it does not attempt to show the depth of the snow in the mountains except as reported by the regular Weather Bureau stations. The average seasonal snowfall and the average annual precipitation for 19 of the cooperative stations located in this region of excessive snowfall are given in Table 1.

As indicated in Table 1, the snowfall stations are all located at high levels. Those located on the eastern slopes of the mountains are drained by streams which empty into mountain lakes. Those on the western slopes are in the watersheds of streams all of whose waters eventually reach San Francisco Bay via the Sacramento and San Joaquin rivers. At most of these stations the average annual precipitation is moderate to heavy. During 1904, 136 inches of precipitation was recorded at Bowmans Dam, while in 1909, 141 inches occurred at La Porte. While the summers are relatively dry and the winters relatively wet throughout the State of California, the seasonal periodicity is less marked in the mountains than elsewhere. Though thunderstorms are not often experienced along the immediate coast, they occur occasionally in the higher parts of the State and furnish what little rain falls during the summer half-year. It is apparent from Table 1 that up to a certain height there is an increase in the total annual precipitation with increase of elevation. Precipitation records covering 40 years are now available at stations extending along the line of the Southern Pacific Company from Sacramento, whose elevation is 71 feet and mean annual precipitation 19.40 inches, to Summit, whose elevation is 7,017 feet and mean annual precipitation 48.07 inches. These show that up to a height of about 6,500 feet there is an average increase of about 0.9 inch of rainfall with every 100 feet increase of height above sea level, the rate of increase being greatest between the 3,000- and 4,000-foot levels. Beyond the 6,500-foot level the rate of increase becomes negative; that is, the mean annual precipitation decreases with height. It should be added that these mountains, though regions of heavy rainfall and excessive snowfall, are not perpetually covered with snow. On the highest peaks the snow disappears in May or June, and usually does not reappear until October. Snowstorms occasionally occur late in the spring, however. For example, 18 inches of snow fell at Blue Canyon on May 6, 1890.

TABLE 1.—*Average seasonal snowfall and average annual precipitation at high stations in northern California.*

Station.	County.	Watershed.	Feet above sea level.	Number of years' record.	Average seasonal snowfall.	Average annual precipitation.
					In.	*In.*
Bishop Creek	Inyo	Mountain lakes	8,500	5	167.7	......
Blue Canyon	Placer	Sacramento	4,695	14	207.2	74.2
Boca	Nevada	Mountain lakes	5,531	29	151.5	20.8
Bowmans Dam	...do	Sacramento	5,500	17	272.7	75.6
Cisco	Placer	.....do	5,939	33	370.0	52.0
Crockers	Tuolumne	San Joaquin	4,452	4	113.2	55.0
Emigrant Gap	Placer	Sacramento	5,230	29	282.7	......
Fordyce Dam	Nevada	.....do	6,500	16	402.4	72.4
Greenville	Plumas	.....do	3,600	18	100.2	44.0
Lake Eleanor	Tuolumne	San Joaquin	4,700	5	158.6	......
Lake Spaulding	Nevada	Sacramento	4,600	17	223.5	78.5
La Porte	Plumas	.....do	5,000	17	284.3	89.2
Quincy	...do	.....do	3,400	18	76.6	48.4
Summerdale	Mariposa	San Joaquin	5,270	13	141.9	55.1
Summit	Placer	Sacramento	7,017	44	419.6	48.1
Susanville	Lassen	Mountain lakes	4,195	22	78.7	21.8
Tamarack	Alpine	San Joaquin	8,000	8	521.3	57.5
Truckee	Nevada	Mountain lakes	5,819	35	195.1	27.1
Yosemite	Mariposa	San Joaquin	3,945	8	106.9	38.6

If the records of a single station for one winter are considered, it is doubtful if greater seasonal snowfalls have been recorded in this country than those presented in Table 2 below.

TABLE 2.—*Some maximum winter snowfalls.*

Place.	Winter.	Depths.		
		Inches.	*Feet.*	*Meters.*
Summit, Cal. (Donner post office)	1879-80	783	65.25	19.89
Do	1889-90	776	64.66	19.71
Tamarack, Cal.	1910-11	757	63.08	19.23

To the average reader the enormity of these figures is perhaps best realized when he translates them to feet. Partly because of the length of the record and partly because of the extreme depth of snow, the seasonal snowfall for Summit, Cal., for a period of 44 years is reproduced herewith in Table 3. An idea of the winter landscape at Summit may be had from figure 7 opposite.

TABLE 3.—*Seasonal snowfall at Summit, Cal.*

[Lat., 39° 19′ N.; long., 120° 10′ W. Elevation, 7,017 feet.]

Winter.	Snowfall.	Winter.	Snowfall.	Winter.	Snowfall.
	Inches.		*Inches.*		*Inches.*
1870–71	300	1885–86	462	1900–1901	440
1871–72	550	1886–87	422	1901– 2	373
1872–73	334	1887–88	345	1902– 3	407
1873–74	200	1888–89	261	1903– 4	434
1874–75	284	1889–90	776	1904– 5	375
1875–76	525	1890–91	335	1905– 6	514
1876–77	178	1891–92	380	1906– 7	602
1877–78	341	1892–93	634	1907– 8	340
1878–79	446	1893–94	511	1908– 9	442
1879–80	783	1894–95	685	1909–10	342
1880–81	154	1895–96	544	1910–11	563
1881–82	492	1896–97	560	1911–12	277
1882–83	299	1897–98	262	1912–13	284
1883–84	482	1898–99	481	1913–14	437
1884–85	202	1899–1900	406		
				Average	419.6

Furnishing, as it does, most of the water that is used for irrigation purposes in California, the snow of the high Sierras is sometimes aptly referred to as the life blood of the State. The farmer is greatly interested because he wishes to know in advance how much water there is available to grow the coming season's crops. The hydraulic engineer, using water for power purposes, is interested for obvious reasons. The hydraulic miner also was until recently interested in the amount of snow. The railroad engineer, concerned with the maintenance of way, is also involved, as the task of keeping a track clear under conditions of such excessive snowfall is not an easy one. (See figs. 2, 6, 10, 12, opposite p. 218.) To the average visitor to this region, however, the amount of snow on the ground is a most impressive sight. Based upon the records of the past nine years, the average amount of snow on the ground at three selected stations is given in Table 4.

TABLE 4.—*Average amount of snow on ground at three California stations on the dates mentioned.*

Dates.	Fordyce dam (6,500 ft.).	Summit (7,017 ft.).	Tamarack (8,000 ft.).
	Inches.	*Inches.*	*Inches.*
Dec. 1	8	9	19
Dec. 15	27	29	40
Jan. 1	42	44	62
Jan. 15	76	82	113
Feb. 1	88	122	165
Feb. 15	94	126	173
Mar. 1	99	127	183
Mar. 15	100	140	194
Mar. 31	101	118	192

THE MEASUREMENT OF SNOW.

It is not the purpose of this paper to discuss the merits of the various methods of measuring snow. For a discussion of that subject the reader is referred to Weather Bureau instrument division Circular E, entitled "Measurement of Precipitation," by Prof. C. F. Marvin. It is sufficient to say that the accurate measurement of precipitation falling in the form of snow is an exceedingly difficult problem, and one which has not yet been satisfactorily solved. Particularly is this true when the snowfall is heavy. It should therefore be borne in mind that some of the snow data here given are subject to correction. The depths of snow quoted herewith are in inches of unmelted snow. Permanently installed stakes bearing snow scales marked in inches are used at Summit, Cal., and at Blue Canyon, Cal., the lengths of these scales being 20 feet and 12 feet, respectively. At Blue Canyon the depth of newly fallen snow is also measured by means of a stick and a canvas snow mat which serves as a plane of measurement. Given a level area, therefore, and one on which the snow is evenly deposited without the inequalities resulting from wind action, the measurement of the depth of the snow on the ground is comparatively simple.

However, the complete measurement of precipitation falling in the form of snow involves a measurement of the water content of the snow. Since the usually adopted ratio of 10 parts of snow being equivalent to 1 part of water is only occasionally true it is apparent that the fundamental problem is that of a proper "catch" of the snow in a suitable instrument. Its subsequent conservation and measurement is not a very difficult matter. The wind is the most troublesome of the disturbing factors. Regarding this problem Prof. Marvin has laid down the following general propositions:

1. In calms and very light winds all gages of reasonable form and dimensions and in similar locations catch sensibly true and equal depths of precipitation.
2. In moderate, brisk, and high winds the catch of gages not screened or protected becomes more and more deficient with the increase in the force of the wind.
3. The deficit in catch due to wind is greater for snow than for rain.
4. In collecting *rain* the deficit in catch, even in strong winds, can be reduced to a relatively small percentage by the use of appropriate wind shields, fences, and other protective barriers, such as have been successfully employed by Nipher, Hellmann, and others.
5. Additional careful experimentation is needed to perfect and improve wind shields and to demonstrate that gages so protected collect snow satisfactorily on windy occasions.

At Blue Canyon and at Summit the Marvin shielded rain-and-snow-gage has been in use for several years. (See fig. 11.) In this instrument, which is 9 feet in height, the collector consists of a cylindrical can, 42 inches deep by 10.85 inches inside diameter, around the mouth of which there is a double arrangement of wind shields. To make a measurement the collector is hung upon a spring balance whose dial has been altered to read directly in inches and hundredths of water (or melted snow), a tare allowance being made for the empty collector. At Blue Canyon the gage has given reasonably satisfactory results, the only difficulty experienced being due to the fact that wet, sticky snow sometimes adheres to the inside top portion of the collector. On one occasion during the past winter a sheet of frozen snow formed completely across the mouth of the collector, while on six other occasions there formed an annular sheet of such width that the "catch" was appreciably deficient. At Summit, on the other hand, the gage, even though constructed in the massive proportions given above, has proved inadequate properly to measure the excessive snowfall. (See fig. 7.) There snow accumulates on the ground to a depth of 20 feet almost every winter; on March 10, 1911, 25 feet 7 inches of snow covered the ground. These measurements are made on level ground, and are not in drifts or banks. It is apparent that a gage of huge proportions

FIG. 1.—Snow fields near the summit of the Sierra Nevada.

FIG. 2.—Southern Pacific Company snowsheds near Emigrant Gap, Cal., in winter.

FIG. 3.—Street scene in Hobart Mills, Cal., in winter.

FIG. 4.—One-story cottages buried to the eaves by snow.

FIG. 5.—Headwaters of Truckee River, near Emigrant Gap, Cal.

FIG. 6.—Snow fields and railroad snowsheds near Cisco, Cal.

FIG. 7.—Summit Hotel at Summit, Cal. (Donner post office), March 18, 1911. A three-story building whose first story is buried under the 26 feet of snow covering.

FIG. 8.—Winter scene at Hobart Mills, Cal., near Truckee, Cal. Row of one-story houses buried in the level snow.

is demanded in snow of so great a depth. When the writer went officially to inspect this station on March 4, 1915, it was with some difficulty that he located the gage, as it was completely submerged in the snow, its topmost point being 19 inches below the snow surface.

The density rather than the depth of the snow is, after all, the important matter. The water content, both of newly fallen snow and of that on the ground at any one time, is the information desired by most people. For new snow the Marvin shielded gage, referred to above, is perhaps the most satisfactory instrument yet devised. For determining from time to time the water available in snow remaining on the ground many and various methods have been tried.

Investigators agree that a desirable method is to carefully weigh an accurately measured volume. Mr. G. H. Willson,[1] section director for California, has long been of the opinion that the best method of determining the water available in snow on the ground is to secure the mean weight of a cubic foot of snow throughout a vertical section of the snow cover. His conclusions have the hearty approval of many engineers and other practical men interested in this problem. In theory the method is perfect. In practice, however, great difficulties are encountered, and the method is not recommended for general use. It is inapplicable when the snow is soft, the consistency of the snow rendering it impossible to get cubes. Moreover, in any kind of snow care is required to form perfect cubes, exactly 1 foot in every dimension, in order to produce reliable results. Furthermore, the method is exceedingly laborious, particularly when the snow is deep, and it often requires more time than the cooperative observers care to give to the work.

The method of measuring the weight of a pailful of snow, reading the density directly on a suitably marked spring balance, and then multiplying the depth of the layer by the density thus determined, has some advantages. But when the snow is deep and has within it ice strata or layers of varying density, as is frequently the case, considerable labor is involved in securing the true average density with the snow pail. The method of cutting out and measuring tubular sections[2] has been used successfully by Prof. J. E. Church, of the University of Nevada, in extensive observations in the Sierras in snow 20 to 30 feet deep. Prof. Church introduced the use of the spring balance for effecting the measurements and otherwise improved the whole apparatus. In California there is a growing demand among mountain snowfall observers for some practicable accurate method of measurement.

CONDITIONS ACCOMPANYING HEAVY SNOWFALL.

It might be contended that the data of heavy snowfall here given are based upon measurements made in canyons and gulches, where the wind has transported the snow, and the figures are therefore misleading. This is not true, however. During the past winter, at a time when 192 inches of snow covered the ground at Summit, eight measurements of the depth of snow on level ground at widely separated points on the mountains in the vicinity of the station were made, with the result that the depths varied only from 190 to 194 inches—that is, but 2 inches on each side of that at Summit. It should also be stated that, as its name indicates, Summit is located at the very apex of the mountains, at the highest point on this branch of the Southern Pacific Railroad. While the exposure is not exactly that of a peak, there is no point in the vicinity more than a few hundred feet higher than the level plot where the snow measurements are made. As a matter of fact the winds at these elevated stations are always relatively light and are in marked contrast with velocities recorded at high stations in the northeastern part of the United States. Based upon the 3 p. m. (Pacific time) observations telegraphed daily to the San Francisco office, the air at Summit was absolutely calm on 44 of the 90 days, or 49 per cent of the time constituting the first three months of 1915. The extremely high wind velocities which often occur in winter in the White Mountains of New Hampshire are unknown in the Sierra Nevada of California. The difference in velocities is probably explained by the difference in distance from storm tracks, the White Mountains being closely adjacent to the numerous storms passing down the St. Lawrence Valley, while the Sierra of California is hundreds of miles south of most storms, and the intervening area is one of uneven topography. As further evidence of the absence of strong wind accompanying snowfall in the Sierras the following is given: When the writer inspected the station at Blue Canyon on March 3, 1915, he observed that the ground under the pine and spruce trees in the vicinity was perfectly bare, while 60 inches of snow covered the ground elsewhere.

By actual measurement a circular area 9 feet 7 inches in radius was found under a large pine tree to be entirely free from snow, while all about it the snow was 5 feet deep. The snow, falling in straight lines through practically calm air, is caught by the branches and when the sun reappears later it melts and the drops of water fall to the ground there melting the small amount of snow that may have accumulated.

PRESSURE RESULTING FROM DEEP SNOW.

To one who has never observed snow of greater depth than 4 or 5 feet, the pressure exerted by a snow cover 15 to 25 feet in depth is almost beyond comprehension. One might naturally infer that the pressure sustained by any object submerged in the snow is simply that of a vertical section of the snow above it. While this may be true for freshly fallen snow of superficial depth it is not true for deep snow which has been deposited in installments and which has intermittently been subjected to freezing and thawing, as is the case in the high Sierras. The following examples of the tremendous pressure of deep snow will suffice: The Marvin shielded rain-and-snow-gage at Summit (see fig. 7), though substantially constructed of steel and sheet iron, was found to be a complete wreck when it was dug out of the snow on March 4 last. In the language of the observer, "It appeared as though a cyclone [i. e., tornado] had struck it." The wind shields had been completely stripped off by the weight of the snow, the guy wires were broken, and the collector had been forced off its pedestal and was lying on the ground beneath. At Blue Canyon a fence, recently built around the railway station, had for its horizontal bars some discarded locomotive boiler flues, 2 inches in diameter. These tubes, made of a good quality of steel, were about 8 feet in length. When the heavy snow came, the vertical pressure it exerted upon these horizontal bars was so great that they were bent to such an extent that they fell to the ground from their sockets in the wooden posts.

The great pressure exerted upon submerged objects by deep snow is worthy of further consideration. It appears that when the sun emerges after a heavy snowfall the surface stratum is partially melted but freezes to a hard crust after sunset. As this process is repeated day after day and the snow decreases in depth, irregularities appearing on the surface show that the snow over most submerged objects melts less rapidly than elsewhere. Humps on the snow surface usually mark the positions of objects beneath. When freezing of the surface stratum follows the

[1] See remarks by Mr. Willson at end of this paper.
[2] See Prof. Henry's remarks at end of this paper.

noonday thaw, the weight of the frozen crust is borne by the submerged object, not only the crust directly over it, but also that for many square feet in every direction. More snow falls and the increased weight must be borne by the object beneath. The process is repeated over and over again, and if the snow becomes sufficiently deep the submerged object is either crushed or forced to the ground. A vertical post deeply submerged in snow is in some respects like a toadstool, in that it must sustain the weight of a large disk which rests horizontally upon the top of its vertical axis.

THE ECONOMICS OF DEEP SNOW.

It is readily apparent that snow of so great a depth as that which falls in the Sierra Nevada Mountains must profoundly affect the economics of that region. Of these influences the most interesting perhaps are those affecting the railroads and their operation. In order to operate during the winter months, the Southern Pacific Company has found it necessary to construct 32 miles of snowsheds between Blue Canyon and Truckee, at a cost of $42,000 a mile over single track and $65,000 a mile over double track. (See figs. 2, 6, and 9.) On an average, $150,000 a year is spent for upkeep and renewals, the expenditure for 1914 having been $65,000 for repairs and $91,000 for renewals. The average life of a shed is 22 years. They are built of massive timbers and are designed to sustain snow 16 feet in depth. When the snow gets deeper than 16 feet it must be shoveled off by hand. At certain points where the railway is located along steep slopes thousands of tons of snow slide over the tops of the sheds every winter. At these places a kind of apron, technically known as a "backoff," 30 to 40 feet in length, is built on the upslope side of the shed in order that the snow may slide harmlessly over the top. Even though timbers 12"×14" in cross section were used in its construction, 48 feet of snowshed near Blue Canyon collapsed because of the weight of the snow on February 15, 1915. The fire hazard is naturally great. For fire-fighting apparatus four trains in summer and two trains in winter are kept under constant steam. All local engines carry pumps, and are followed by tank cars filled with water for fire-fighting purposes. Concrete snowsheds have been built on other railroads to offset the fire hazard, but their initial cost renders that form of construction almost prohibitive. One other feature of this region is noteworthy. Flat-roofed houses are conspicuous through their absence. The gables of all houses, and particularly dwellings, are built at sharp angles in order that the snow may slide off easily.

HISTORICAL INFLUENCES.

Needless to add, the deep snows of the high Sierras have played a part in the history of the State of California. While the mountains themselves acted as a barrier, the deep snows made them well nigh impassable for about six months of the year. One incident in the early history of California is significant in this connection. For several years preceding the discovery of gold in California in 1848, there had been an increasing number of settlers coming from all over the continent. In the summer of 1846 the influx had been unusually large, several hundred immigrants having come via Truckee, along the route now marked by the Southern Pacific Railroad. The Donner party, consisting of 83 persons, accompanied by a numerous caravan of "prairie schooners," cattle, etc., had been delayed by mishap and dissension en route. On October 31, 1846, they started the steep ascent on the eastern side of the Sierras. A few days later, when they had advanced no farther than a small lake (now known as Donner Lake) but a few miles from Truckee, a typical winter storm brought snow of so great a depth that the horses and cattle were submerged and frozen, and the party was cast into despair at the prospect of spending a winter without shelter or provisions. The deeper snow of the higher altitudes rendered advancement almost impossible, while retreat appeared to be hopeless. The garrison at one of the California forts, anticipating the distress of the Donner party, sent two Indians with provisions for its relief. When, in midwinter, the food supply again ran low, a group of 22 desperate men, known to posterity as the "Forlorn Hope," started to cross the summit of the mountains. Of these, but 7 eventually reached the fertile Sacramento Valley. * * * Death also reduced the number of those encamped at the lake. From time to time other parties attempted the apparently impossible feat of crossing the mountains. On February 19, 1847, 22 feet of snow covered the ground in the vicinity of the camp. When succor finally came in the late winter, but two men were found alive. * * * Of the 83 who started the ascent the preceding October, 42 perished during the fateful winter. The story of the privations of the Donner party is one of the most pitiful tales in American history.

Modern methods of transportation have now eliminated the barrier of the snows. In the construction of the various railroads, engineering feats of high order were necessary to contend with previously unheard of depths. While the part played by the snow is not so spectacular at the present time as it was during the days of the pioneer, the influence is none the less important. Modern practices have changed the snow that was formerly an impediment to progress, into one of the valuable resources of the Commonwealth of California

DISCUSSION.

1. The method of cutting out a tubular section of snowfall and determining the water content by melting was suggested in 1882, in Instructions for Voluntary Observers of the Signal Service, Washington, 1882, page 74; but the practical application of the idea of determining the water equivalent of snowfall on the ground by weighing a tubular section was first worked out by Mr. Robert E. Horton at Utica, N. Y., in the winter of 1903–4 (Monthly Weather Review, **33**: 196.) Later the method was successfully used by the Weather Bureau on the recommendation of Prof. H. C. Frankenfield, and apparatus to carry out the idea was devised by Prof. C. F. Marvin, as described in Instrument Division Circular E (3d ed.), Measurement of Precipitation. Prof. J. E. Church, jr., of the University of Nevada, Reno, Nev., introduced the use of a spring balance and otherwise developed the apparatus, especially with reference to its use in very deep snow banks, such as are found in the Sierra Nevada. Prof. Church's apparatus is described and illustrated in the Quarterly Journal of the Royal Meteorological Society (London) for January, 1914, also in Meteorologische Zeitschrift for January, 1913, and in Scientific American Supplement for September 7, 1912.

The most efficient and accurate apparatus for the purpose of determining the snow density where the depths are not excessive is doubtless that devised by Mr. B. C. Kadel, while in charge of the experiment station maintained jointly by the Forest Service and the Weather Bureau at Wagon Wheel Gap, Colo., in 1911.

FIG. 9. Entrance to Southern Pacific Company's snowsheds, Blue Canyon, Cal., 1889-90. Snow is 165 inches deep on the level.

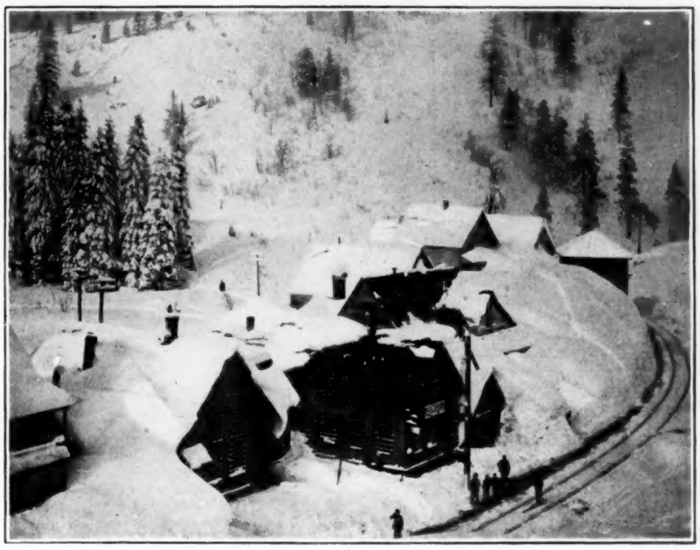

FIG. 10.—Blue Canyon, Cal., during the winter of 1893-94.

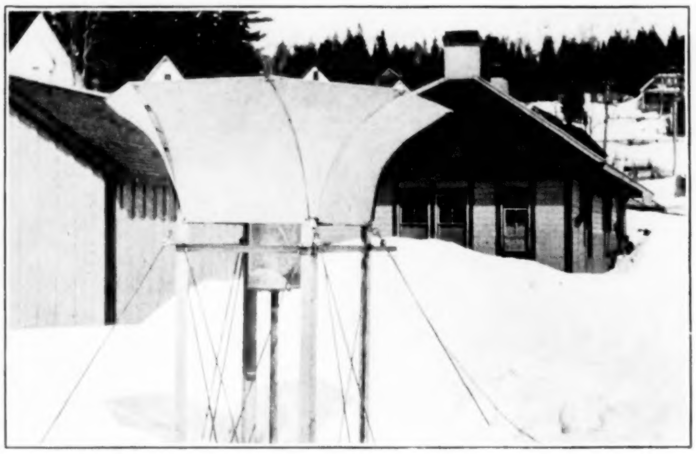

FIG. 11.—The Marvin shielded rain-and-snow gage in operation at Blue Canyon, Cal.

FIG. 12.—A railroad push plow clearing the tracks of the Southern Pacific Company near Hobart Mills, Cal. Note depths at side of cleared tracks.

The following description of the Kadel apparatus is extracted from an unpublished manuscript by Mr. Kadel:[3]

For the purpose of obtaining samples of snow, tubes of No. 16 gauge galvanized iron, with an inside diameter of 5.94 inches, which gives the relation 1 pound of snow equals 1 inch of water, were used. Each tube consists of a 2-foot section and a 3-foot section, with a notched collar attached to the 2-foot section in such fashion that both tubes may be joined together. When a sample is desired, the tube is set down rather forcibly into the snow, so that the lower end rests on the ground. A specially designed auger is then screwed down through the imprisoned snow to the bottom, when a pin that passes through a hole in the auger handle rests on the top rim of the tube. The whole is then withdrawn by lifting the tube, the weight of the auger and the snow sample being supported by the cross pin. The snow is then emptied into a pail and weighed on a spring balance.

The apparatus above described is shown in figure 13. It leaves no uncertainty as to the accuracy of the final results after the sample has been taken, and likewise it

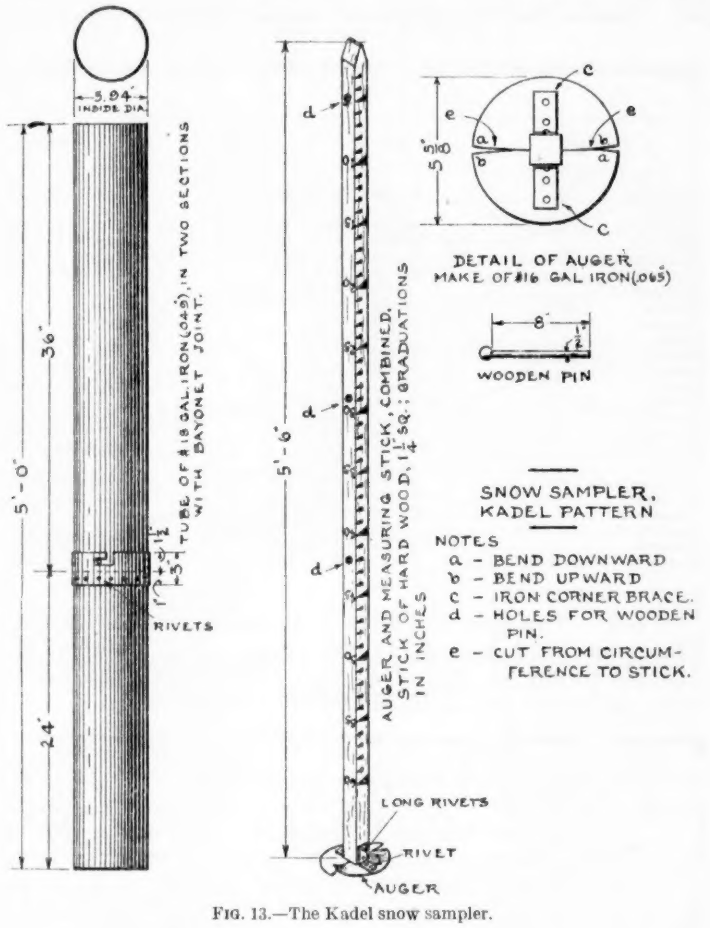

FIG. 13.—The Kadel snow sampler.

is always possible to secure an unbroken sample, even when the snow is loose and granular in structure.

Some comparative measurements were made at Wagon Wheel Gap, Colo., under uniform conditions of depth and texture of snow, using the three different forms of snow density apparatus then available, viz, (1) the Kadel apparatus, diameter of collecting tube 5.94 inches; (2) the Weather Bureau apparatus, diameter of collecting tube 2.75 inches; (3) the Church apparatus, diameter of cutting edge 1.5 inches. The records of these measurements differed considerably among themselves, the maximum difference amounting to 16.7 per cent, but the Kadel apparatus seemed to give more consistent results than did the apparatus having a relatively smaller collecting tube. The problem of developing a portable density apparatus is still receiving the attention of the bureau.—*A. J. Henry.*

2. The idea of obtaining the density of the snow in Nevada by cutting out cubes of 1 foot each from the different depths in the snow bank and weighing them, originated with Mr. W. H. Kirkbride, division engineer of the Southern Pacific Co., who is in charge of that division of the railroad crossing the sierra. In January, 1914, while on an inspection tour at Summit, Placer County, Cal., he caused a cubic foot of snow to be cut from each of different depths in the snow bank and had them weighed. The Weather Bureau observer at that station, E. F. Stewart, included the results in his snow report to this office for that month.

I then requested other observers in the high Sierra, where the snow packs solid, to make similar tests, and these have been carried out quite regularly since February, 1914. The snow that falls in the Sierra is very wet; in the higher levels it soon packs and freezes solid, thus there is but little difficulty experienced in cutting out blocks of any desired size and shape from levels a foot or so below the surface. The surface layer is not always so firm, and often one can not cut cubes from it.

I believe that this method of determining the snow density (water equivalent) is not applicable in many sections of the country, because the dryness of the snow does not permit it to pack firmly or solidly, as it does in the Sierra Nevada. In fact, in those mountains the snow that falls during very cold weather and during northeast (dry) winds will not admit of the use of this method, but these conditions occur so rarely that they may well be neglected.

There is one objection that may be raised against this method, viz, the cubes may not always be cut with absolute exactness. Probably this is the fact in many cases; but if there is any error it will fall as often on the plus side as on the minus side, and as these measurements are made at widely separated stations, the natural variations in the snow density probably more than mask any slight inaccuracies of the method which is only intended to secure approximate results. Even the most exact measurements made by any method would only result in approximately correct data, because of the immense area of the snow fields and the few tests that could be available, under any conditions, on which to base a result. The real and great objections to the method lie in the difficulty of digging deep into the banks of snow for the purpose of securing several samples at different depths, and the necessity of waiting to make the samplings until the snow packs.

The real merit of this method over all others is that when the snows are sampled at several different depths it shows up the ice strata in the cover and thus affords a basis for forcasting the rate of melting. The merit of the method is best attested by the approval it has received at the hands of such eminent engineers as C. E. Grunsky, president of the American Engineering Corporation; H. C. Vensano and A. L. Trowbridge, of the Pacific Gas & Electric Co.; and its originator, W. H. Kirkbride, division engineer of the Southern Pacific Co.—*G. H. Willson.*

[3] See also this REVIEW, January, 1913, 41: 160, 2d col.

THE EFFECT OF WEATHER UPON THE YIELD OF POTATOES.

By J. WARREN SMITH, Professor of Meteorology.

[Dated: Weather Bureau, Columbus, Ohio, April 19, 1915.]

CONTENTS.

INTRODUCTION.

Potatoes are a cool-weather crop, and undoubtedly originated in the mountains of South America. The first mention of this plant was in a Spanish history of Peru, in 1550, where it was stated that the natives near Quito cultivated it.

In 1897, in going from Callao to Oroya, Peru, Prof. R. DeC. Ward noticed in a region at an elevation of 10,500 feet above sea level a district that is famous for its potatoes and where little else is grown. Ward states that the first part of his journey over this remarkable railroad was through fields of sugar cane and cotton where the elevation was but little above sea level. At 5,000 feet elevation a zone of fruit trees was passed through, at 10,500 feet the potato district, and at a still higher elevation only grass was found.

While this region is nearly under the equator the mountain districts are cool. At Cuzco, the old capital of the Incas, the average annual temperature is only 52° F. and varies from 48° in July to 54° in November. This place is 11,100 feet above sea level and is only slightly higher than the potato district mentioned by Ward.

Figure 1 and Table 1 show that in the United States the potato has made its greatest development in the cooler sections of the country where the mean annual temperature is between 40° and 50° and where the mean temperature of July is not over 70°. Further, the greatest yields of potatoes per acre, as shown in figure 2, are in those States where the mean annual temperature is below 45° and where the mean of the warmest month is not far from 65°.

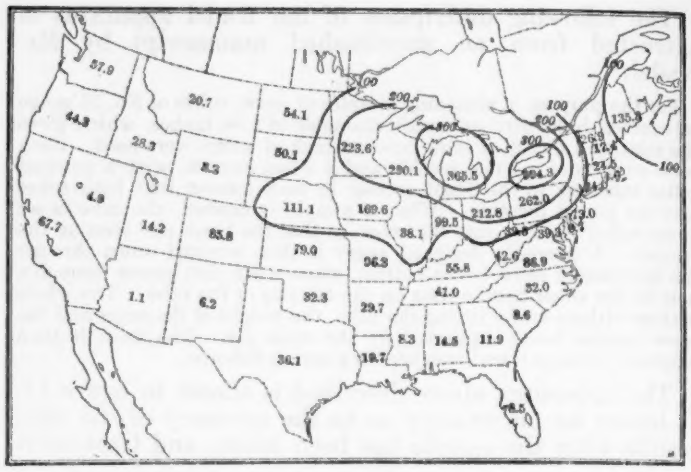

FIG. 1.—Number of thousands of acres planted to potatoes in each State in 1909. (Based on U. S. census reports.)

TABLE 1.—*Potato acreage, by States, in 1909, based on United States census.*

State.	Acreage.	State.	Acreage.
Alabama	14,486	Nebraska	111,151
Arizona	1,151	Nevada	4,864
Arkansas	29,719	New Hampshire	17,370
California	67,688	New Jersey	72,991
Colorado	85,839	New Mexico	6,230
Connecticut	23,959	New York	394,319
Delaware	9,703	North Carolina	31,990
Florida	8,509	North Dakota	54,067
Georgia	11,877	Ohio	212,808
Idaho	28,341	Oklahoma	32,295
Illinois	138,052	Oregon	44,265
Indiana	99,504	Pennsylvania	262,013
Iowa	169,567	Rhode Island	4,649
Kansas	79,025	South Carolina	8,610
Kentucky	55,750	South Dakota	50,052
Louisiana	19,655	Tennessee	40,963
Maine	135,799	Texas	36,092
Maryland	39,299	Utah	14,210
Massachusetts	24,459	Vermont	26,859
Michigan	365,487	Virginia	86,927
Minnesota	223,692	Washington	57,897
Mississippi	8,342	West Virginia	42,621
Missouri	96,259	Wisconsin	290,185
Montana	20,710	Wyoming	8,333

Yield.—The area devoted to potatoes in the United States in 1912 was 3,711,000 acres. The number of bushels produced that year was 420,647,000, the farm value of which was $212,550,000 on December 1.

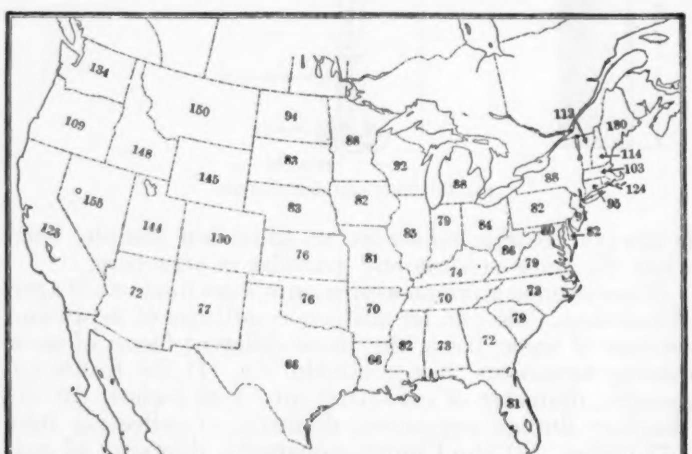

FIG. 2.—Average yield of potatoes, in bushels per acre, in each State for 1900-1909. (U. S. Dept. Agric. Yearbook for 1913.)

In figure 1 the number of thousands of acres planted to potatoes in each of the United States in 1909 is given.

While this chart does not take into consideration the variation in size of the different States, it would present much the same appearance if it should show the production per square mile of area. The greatest proportion of Irish potatoes is grown in the northeastern quadrant of the United States.

In figure 2 the yield of potatoes in bushels per acre is shown for each State for the 10 years, 1900 to 1909, inclusive. The yield in Maine was 180 bushels per acre, while in the central Rocky Mountain States it was over 140 bushels per acre.

In Ohio potatoes rank fourth in importance in the staple crops, corn being first, oats second, and wheat third. The acreage devoted to potatoes in Ohio in 1912 was 104,812 and the yield was 10,579,701 bushels. Fully one-half of the potatoes produced in Ohio are grown in the northeast quarter of the State.

The mean annual temperature for the northern third of Ohio is 49.4° and the mean temperature for the warmest month is 72.5°.

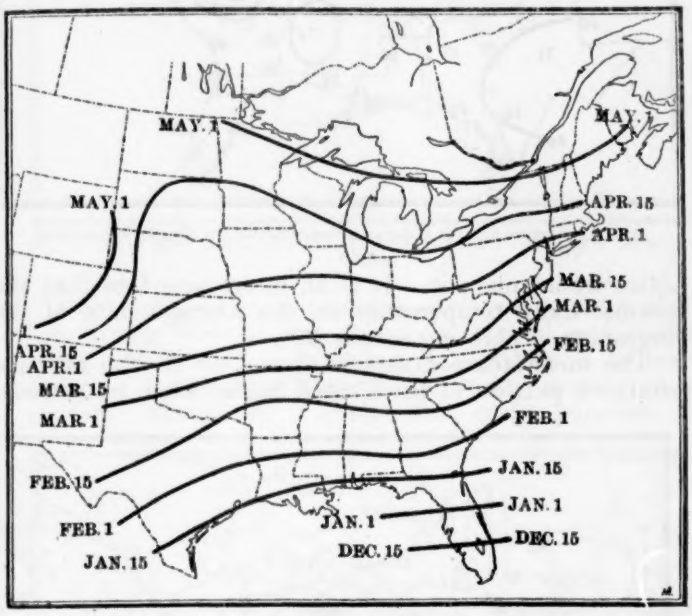

FIG. 3.—Average date on which planting of early potatoes begins. (U. S. Bureau of Crop Estimates.)

Dates of planting and harvesting potatoes.—In studying the effect of the weather upon the growth and development of any plant it is necessary to know the season during which it is making its best growth.

In figures 3 and 4, therefore, the average dates when *early* potatoes are planted and when dug are indicated. Figure 3 shows that early potatoes are planted in southern Florida in December and along the Gulf coast early in January. The time of the beginning of planting then progresses with a fair degree of regularity northward until it is the 1st of May in Upper Michigan and northern Maine. The effect of the Appalachian Mountains and of the cool waters of the Lakes in delaying planting is plainly indicated.

The harvesting of early potatoes, as shown in figure 4, begins in March in southern Florida, and about September 1 in northern Maine. From these two charts figure 5 was prepared, which gives the total number of days necessary for the growth of early potatoes in different sections of the country east of the Rocky Mountains. The greatest number of days between the beginning of planting and digging is seen to be across the central part of the country and in northern Maine. The least number of days is 76 in northeastern Ohio.

In figures 6, 7, and 8 similar charts are given to show the time of planting, timo of digging, and the days necessary for the growth and development of *late* potatoes. It will be at once noted that while the planting and digging of early potatoes progresses from south to north similar work on the late potato crop progresses from the north southward.

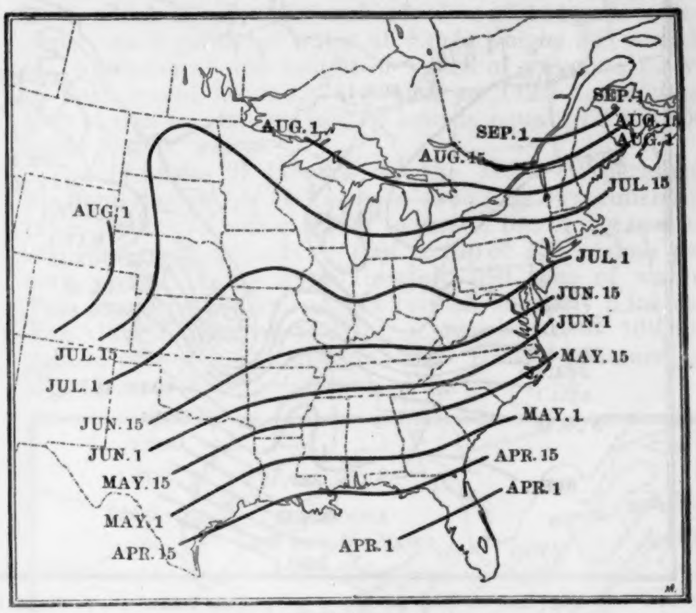

FIG. 4.—Average date on which digging of early potatoes begins. (U. S. Bureau of Crop Estimates.)

The earliest date for the beginning of planting late potatoes is April 20 in the vicinity of New York, and the latest date December 1 at Miami, Fla. The digging of late potatoes begins in September in the extreme northeast, in the vicinity of Chicago, and in the central Appalachian Mountain district. In extreme southern Florida late potatoes are not dug until the first of February.

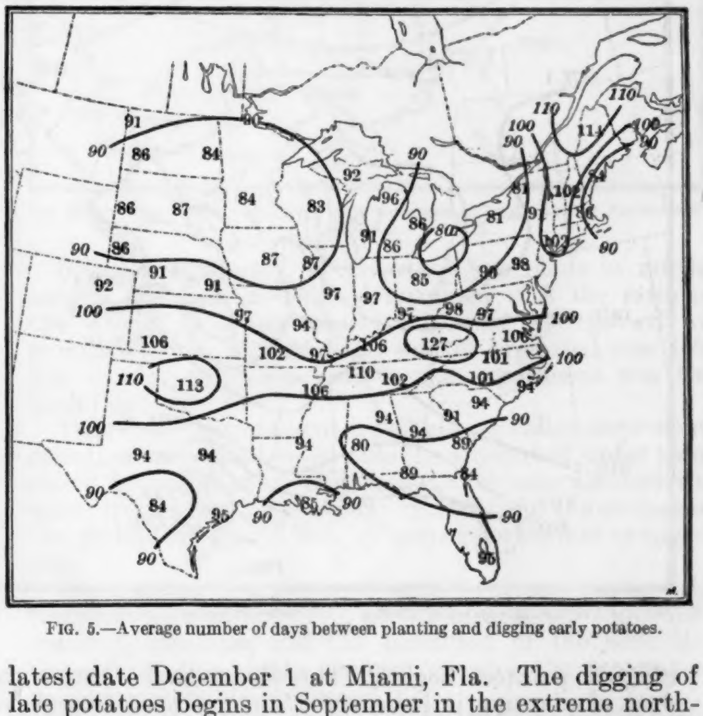

FIG. 5.—Average number of days between planting and digging early potatoes.

One interesting feature in figure 8 is that while the number of days for the growth of late potatoes is greater than it is for early potatoes in the northern part of the United States, it is not so great in southern States. Another is that the higher elevations in Virginia and

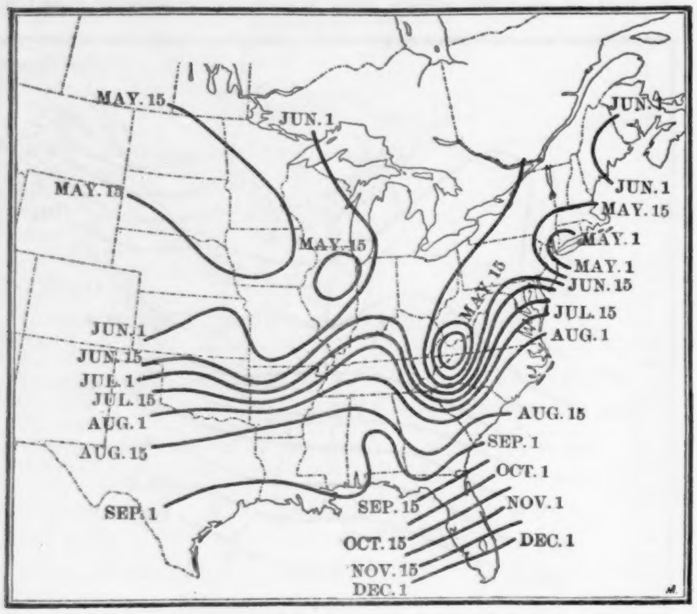

FIG. 6.—Average date on which planting of late potatoes begins. (U. S. Bureau of Crop Estimates.)

North Carolina partake of the characteristics of the more northern districts, probably because of the similarity in temperature.

On the chart in figure 9 there has been entered the mean daily temperature for the date when the planting

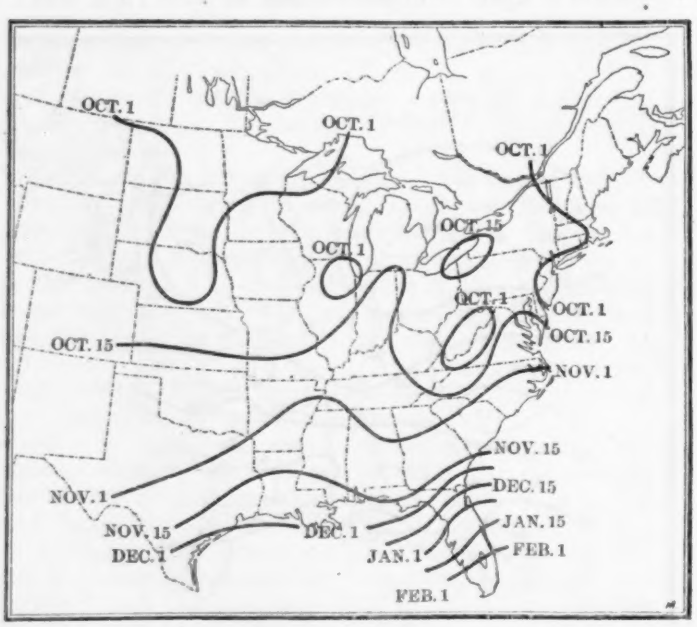

FIG. 7.—Average date on which digging of late potatoes begins. (U. S. Bureau of Crop Estimates.)

of early potatoes begins. This shows that whether the date of planting is February 15 in northern Georgia or May 1 in the northern portion of the United States the seasonal rise has brought the temperature close to 45°F.

When the mean temperature value is much lower than this, as at New York, it is apparent that the earlier planting date is local and possibly artificial and is slightly earlier than the average for that section of the country. Also when the temperature is much higher than 45°, as at Albany, N. Y., the average date of planting may be slightly later than a further investigation of planting

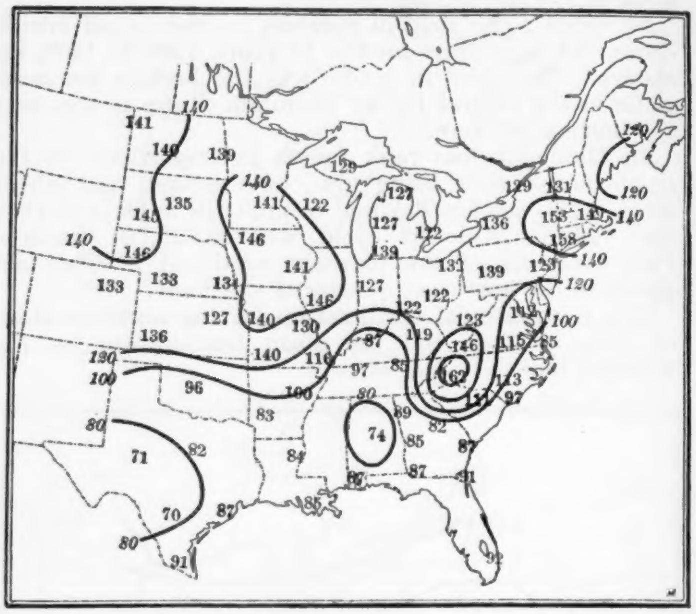

FIG. 8.—Average number of days between planting and digging late potatoes.

dates would place it. It is an interesting fact that the normal daily temperature on the average date of the beginning of planting corn is 55°.

The mean temperature is above 45° in the extreme southern portion of the United States when early pota-

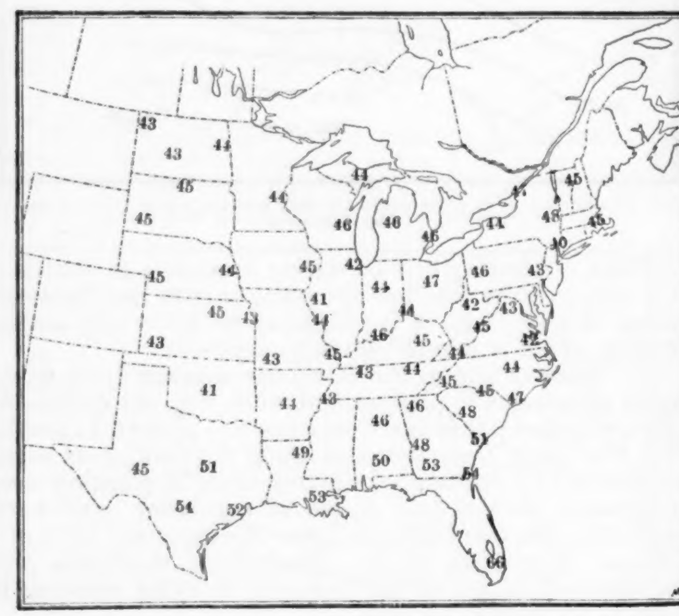

FIG. 9.—Mean daily temperature (°F.) on the date when the planting of early potatoes begins.

toes are planted because the normal daily temperature does not reach so low as that in any season of the year.

The average daily temperature on the date that late potatoes are planted, as shown by figure 10, indicates no such uniform value as is the case with early potatoes. One interesting thing, however, is that while the planting

of late potatoes is much earlier in the high altitude districts of Virginia and North Carolina than at other places in that latitude, the daily temperature at the time of planting is lower than at nearby lower-altitude points and agrees with the temperatures in the northern portions of the country.

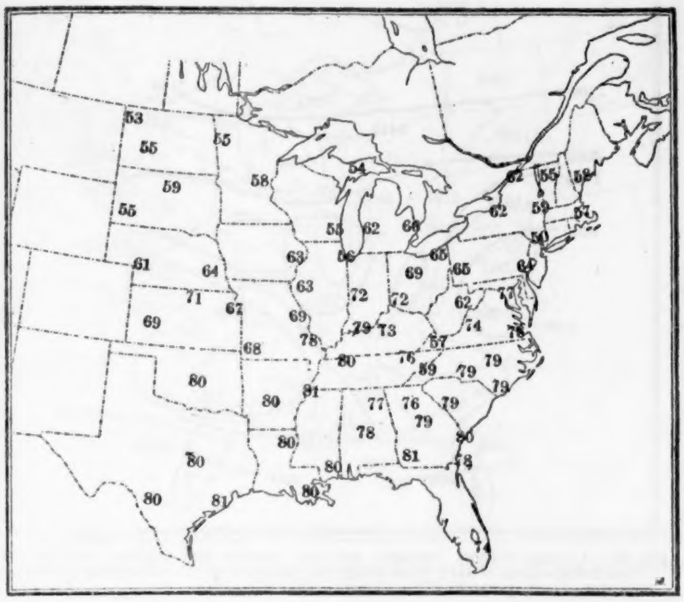

FIG. 10.—Mean daily temperature (°F.) on the date when the planting of late potatoes begins.

Frost dates.—Figure 11 shows the average dates of the last killing frost in the spring in central and eastern United States. A comparison with figure 3 indicates that the last killing frost in the spring occurs, on an average, about one month after early potatoes are

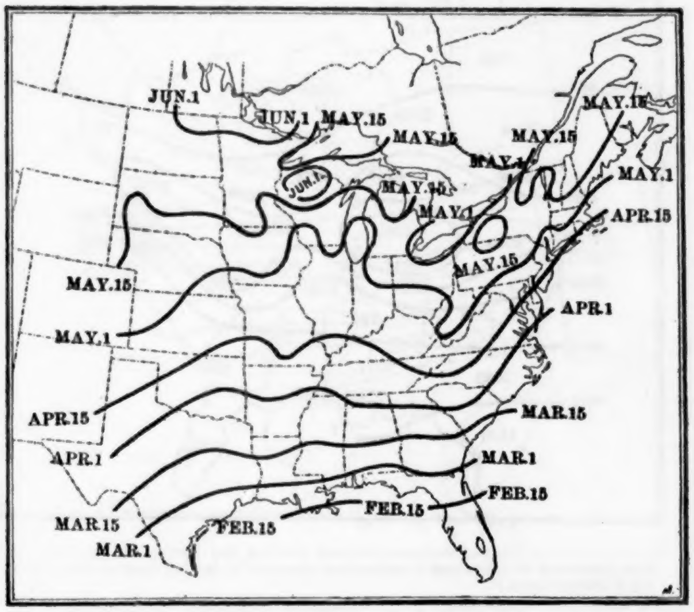

FIG. 11.—Average date of last killing frost in spring. (From Weather Bureau bulletin V.)

planted. In Table 16 it is shown that the average time that it takes early potatoes to come up, at Wauseon, Ohio, is 17 days. This indicates that early potatoes are very apt to be cut back by frost.

In figure 12 there is given the average dates of the first killing frost in the fall. This agrees very closely with the beginning of digging of late potatoes as shown in figure 7, as would be expected.

WATER REQUIREMENTS OF POTATOES.

Water requirements of potatoes.—A rainfall of 1 inch means a fall of 6,272,640 cubic inches of water on 1 acre of land, which equals 3,630 cubic feet or 27,154 gallons per acre. As 1 gallon of water at 62° F. weighs 8.3 pounds (U. S. measure), the weight of 1 inch of water on 1 acre of land would be 225,378 pounds or 112.7 tons. One inch of rain on 1 square mile of land is equal to 2,323,200 cubic feet of water.

Prof. Charles D. Woods, of the Maine Experiment Station, states that it has been found by experiment it takes about 425 tons of water to grow 1 ton of dry matter of potatoes, and therefore that a crop of 200 bushels per acre would require approximately 650 tons of water. This would be equivalent to a rainfall of nearly 6 inches. The Ohio Farmer states that it requires over 108,000 gallons of water to mature a single acre of potatoes, or slightly over 4 inches of rain.

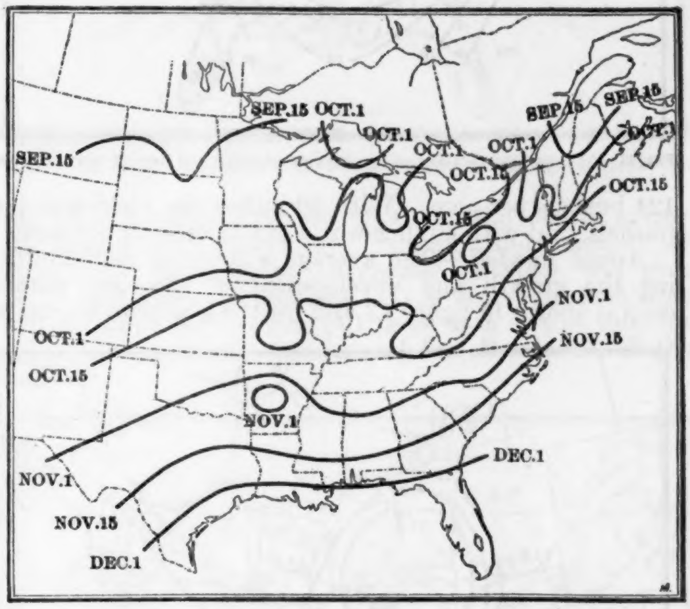

FIG. 12.—Average date of first killing frost in autumn. (From Weather Bureau bulletin V.)

Briggs and Shantz, in investigations made in northeastern Colorado in 1911, determined that the ratio of the weight of water absorbed during the growth of potatoes to the weight of dry matter produced was 448. The variety of potato used in the experiment was the Irish Cobbler.

This water requirement is sometimes called the "transpiration ratio" and represents the amount of water transpired by the plant. It does not take into account the water from a rainfall that may run off from the surface of the ground or that is lost by seepage or surface evaporation.

The amount of water transpired by a crop varies with temperature and humidity of the atmosphere, the wind velocity, sunshine, and the condition of the soil; also the size of the plants themselves, and the amount of moisture available in the soil.

King, in the more humid climate of Wisconsin, in 1892–1895, found that it required only 423 tons of water to produce 1 ton of dry matter of potatoes. Von Seelhorst, in 1896–1898, at Göttingen, Germany, found the water requirement of potatoes to be only 281, but the experi-

ments of Widtsoe, at Logan, Utah, agree very closely with those of Briggs and Shantz in Colorado.

In one experiment in Utah it was found that with an application of water at the rate of 9 inches the yield was

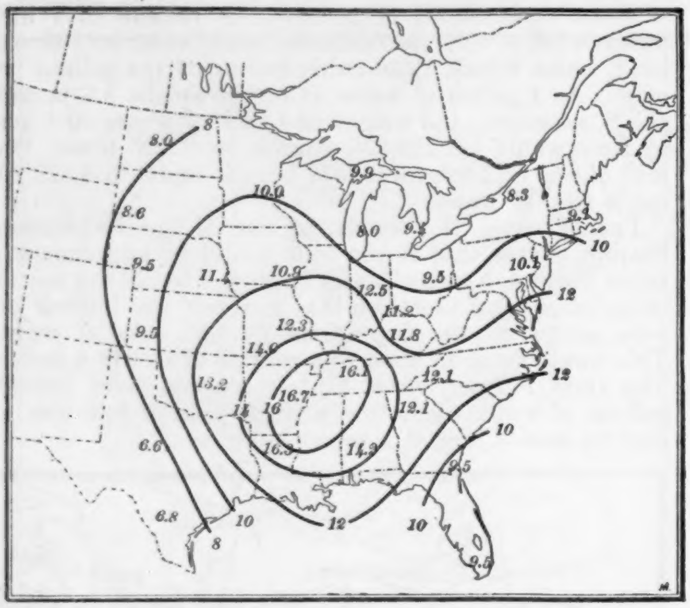

FIG. 13.—Average total rainfall (inches) between planting and digging early potatoes.

124 bushels per acre. With 20 inches the yield was 446 bushels, and with 40 inches it was 523 bushels per acre.

Actual rainfall.—The average amount of rainfall during the growth and development of the early potato crop is shown in figure 13 and for the late potato crop in

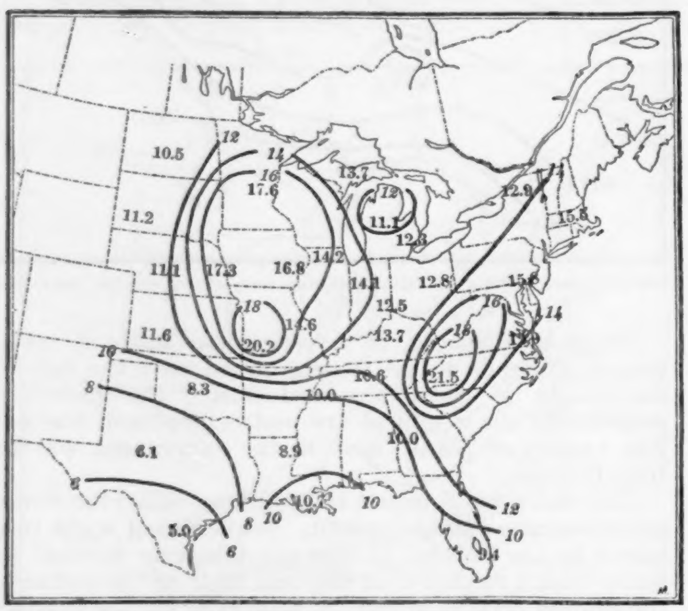

FIG. 14.—Average total rainfall (inches) between planting and digging late potatoes.

figure 14. In comparing these charts with those in figures 1 and 2 it will be seen that the best yield of potatoes is not where the greatest amount of rain falls.

TEMPERATURE REQUIREMENTS OF POTATOES.

The statements made in the first part of this article indicate that potatoes are a cool-weather crop, and studies which are elaborated later make this matter plain, but it seems wise at this point to refer to figures 15 and 16.

Thermal constants for potatoes.—The "thermal constant" of a crop is the average sum of the daily effective

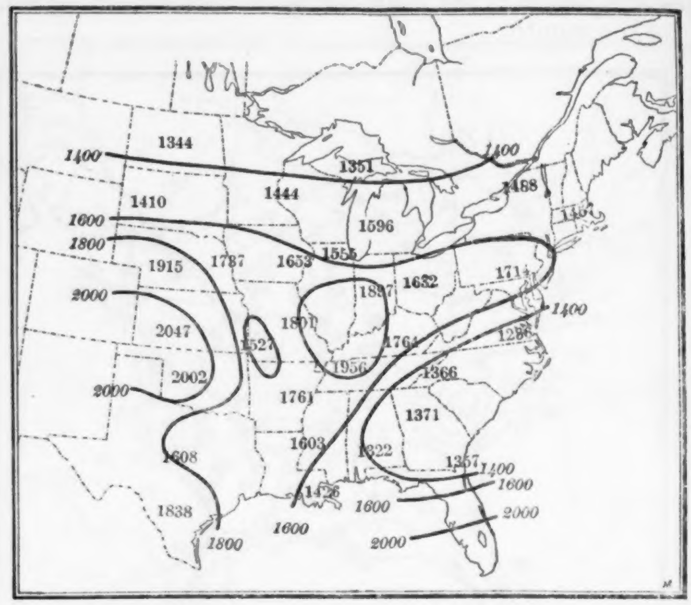

FIG. 15.—Average thermal constants between planting and digging early potatoes. (Figures state sums of daily mean temperatures above 43° F. during the growth and maturing of early potatoes.)

temperatures necessary to bring it to maturity. To determine the effective temperatures the writer has considered that part of the daily mean temperature

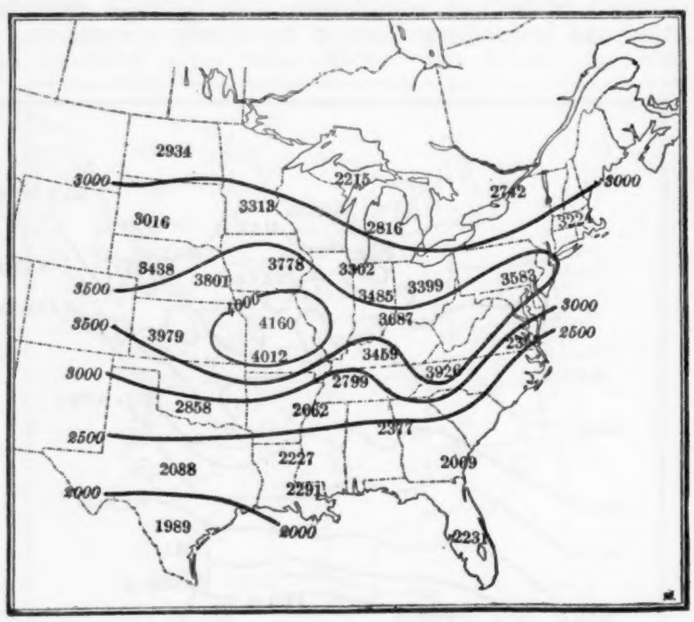

FIG. 16.—Average thermal constants between planting and digging late potatoes. (Figures state sums of daily mean temperatures above 43° F. during the growth and maturing of late potatoes.)

that is above 43° F. For example, a day with an average temperature of 48° has an "effective temperature" of 5°.

In figure 15 there is given the sum of the average daily degrees of heat above 43° between the date of planting and the date of harvesting of early potatoes. In figure 16 similar data are given for the late potato crop.

In general the greatest amount of heat necessary to grow and mature the potato crop is in that locality where the greatest amount of rain falls, and not necessarily where the time of growth is longest. The soil moisture carries the plant food to the roots of a crop where it is utilized by solar energy. Other things being equal, the greater the moisture the greater the amount of energy necessary to work the plant food into vegetable tissue.

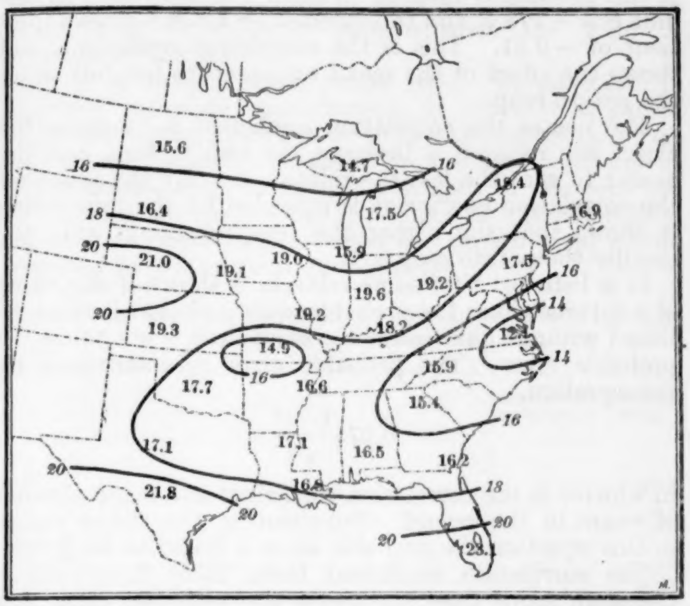

FIG. 17.—Average excess of the daily mean temperature over 43°F. between the planting and the digging of early potatoes.

This is particularly emphasized in figures 17 and 18 which show the average excess of the daily mean temperature over 43°F. for early and late potatoes, respectively. The daily amount of heat necessary for the potato crop is greatest in central districts where the rainfall is greatest. It is least in northern districts,

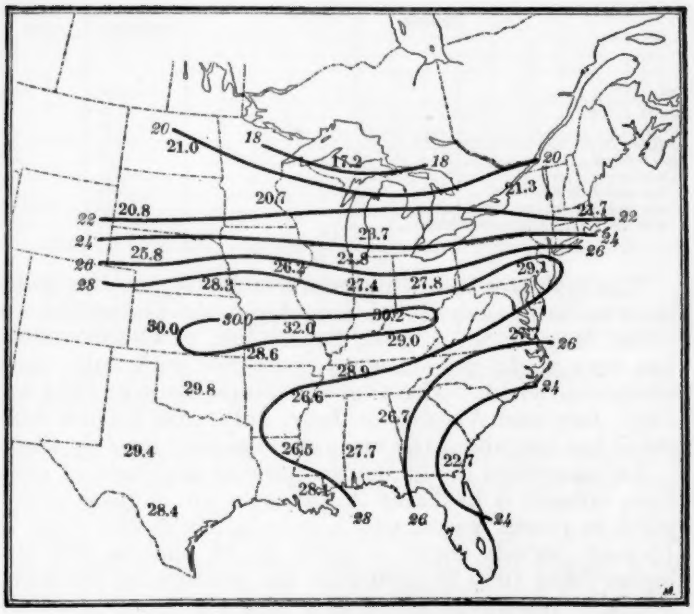

FIG. 18.—Average excess of the daily mean temperature over 43°F. between the planting and the digging of late potatoes.

particularly for late potatoes, although the growing season is longer there.

Figures 19 and 20 show the percentage of possible sunshine that is experienced from planting to harvesting of potatoes. A study of all of the charts giving the sunshine, temperature, rainfall, and number of days from planting to harvesting potatoes will give some interesting correlations. It is regretted that time will not allow for working out these data at this time for a larger number of stations and for all sections of the country.

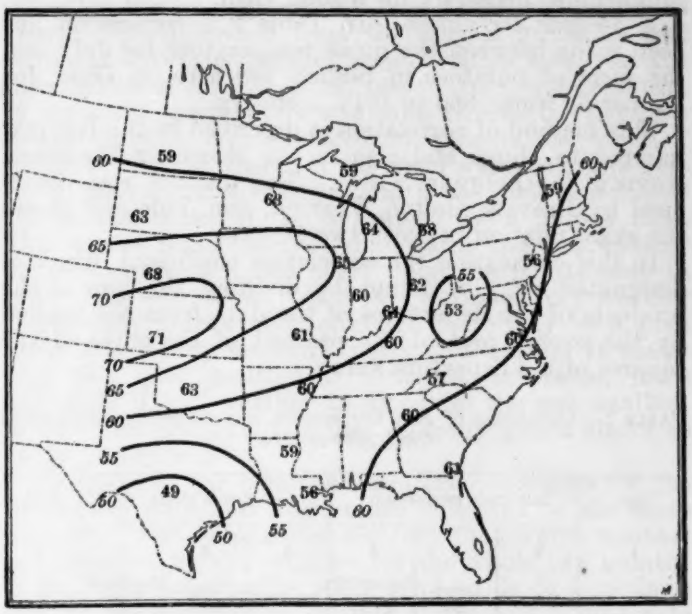

FIG. 19.—Percentage of possible sunshine between planting and digging of early potatoes.

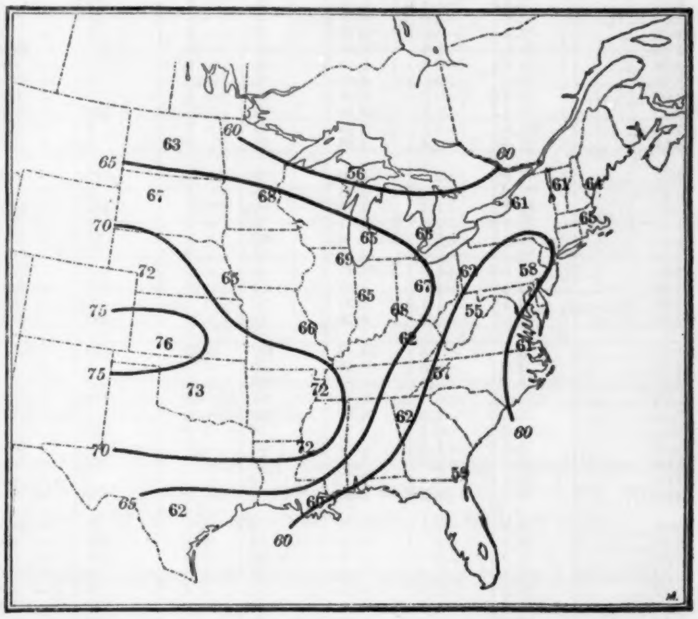

FIG. 20.—Percentage of possible sunshine between planting and digging of late potatoes.

CORRELATION OF WEATHER AND POTATO YIELD.

An early study.—In the MONTHLY WEATHER REVIEW for May, 1911, **39**: 792, the writer, in discussing the scientific method of correlation used the effect of the

weather upon the yield of potatoes to illustrate the process. The period covered was from 1883 to 1909 and seemed to show that temperature had a greater effect on the yield in Ohio than rain, and that a cool summer was necessary for a good yield.

A 55-year correlation.—In Table 2 a correlation has been made between the mean temperature for July and the yield of potatoes in bushels per acre, in Ohio, for the period from 1860 to 1914, inclusive.

This method of correlation is described in the REVIEW referred to above and also in the MONTHLY WEATHER REVIEW for February, 1914. The method was developed by Bravais, Galton, Pearson, and Yule and shows the exact relation between two factors.

In this correlation the correlation coefficient, which is designated as r, is found by dividing the sum of the products of the departures of the data from the normal by the square root of the product of the sums of the squares of the departure values.

TABLE 2.—*Correlation of July temperature, and the yield of potatoes in Ohio, 1860 to 1914.*

Year.	July mean temperature.			Potato yield.			3×6.
1	2	3	4	5	6	7	8
	Mean.	Departure.	Square of departure.	Amount.	Departure.	Square of departure.	
	°F.	°F.		Bushels.			
1860	72.0	−1.6	2.56	97	+19	361	− 30.4
1861	70.2	−3.4	11.56	81	+ 3	9	− 10.2
1862	72.9	−0.7	0.49	64	−14	196	+ 9.8
1863	72.0	−1.6	2.56	66	−12	144	+ 19.2
1864	75.2	+1.6	2.56	74	− 4	16	− 6.4
1865	71.1	−2.5	6.25	66	−12	144	+ 30.0
1866	75.6	+2.0	4.00	70	− 8	64	− 16.0
1867	72.9	−0.7	0.49	66	−12	144	+ 8.4
1868	80.2	+6.6	43.56	72	− 6	36	− 39.6
1869	73.1	−0.5	0.25	85	+ 7	49	− 3.5
1870	76.4	+2.8	7.84	70	− 8	64	− 22.4
1871	72.2	−1.4	1.96	87	+ 9	81	− 12.6
1872	75.6	+2.0	4.00	74	− 4	16	− 8.0
1873	73.0	−0.6	0.36	76	− 2	4	+ 1.2
1874	75.0	+1.4	1.96	62	−16	256	− 22.4
1875	73.5	−0.1	0.01	96	+18	324	− 1.8
1876	75.6	+2.0	4.00	60	−18	324	− 36.0
1877	73.8	+0.2	0.04	82	+ 4	16	+ 0.8
1878	76.8	+3.2	10.24	65	−13	169	− 41.6
1879	75.9	+2.3	5.29	77	− 1	1	− 2.3
1880	73.1	−0.5	0.25	75	− 3	9	+ 1.5
1881	75.6	+2.0	4.00	39	−39	1,521	− 78.0
1882	70.7	−2.9	8.41	75	− 3	9	+ 8.7
1883	72.1	−1.5	2.25	99	+21	441	− 31.5
1884	71.5	−2.1	4.41	76	− 2	4	+ 4.2
1885	75.2	+1.6	2.56	82	+ 4	16	+ 6.4
1886	72.0	−1.6	2.56	86	+ 8	64	− 12.8
1887	77.9	+4.3	18.49	49	−29	841	−164.7
1888	72.1	−1.5	2.25	94	+16	256	− 24.0
1889	72.5	−1.1	1.21	81	+ 3	9	− 3.3
1890	73.0	−0.6	0.36	58	−20	400	+ 12.0
1891	69.0	−4.6	21.16	101	+23	529	−105.8
1892	73.0	−0.6	0.36	75	− 3	9	+ 1.8
1893	74.5	+0.9	0.81	69	− 9	81	− 8.1
1894	74.3	+0.7	0.49	64	−14	196	− 9.8
1895	71.6	−2.0	4.00	76	− 2	4	+ 4.0
1896	73.2	−0.4	0.16	84	+ 6	36	− 2.4
1897	75.5	+1.9	3.61	64	−14	196	− 26.6
1898	76.0	+2.4	5.76	86	+ 8	64	+ 19.2
1899	74.1	+0.5	0.25	78	− 1	1	− 0.5
1900	74.1	+0.5	0.25	86	+ 8	64	+ 4.0
1901	78.1	+4.5	20.25	72	− 6	36	− 24.0
1902	74.0	+0.4	0.16	93	+15	225	+ 6.0
1903	72.9	−0.7	0.49	91	+13	169	− 9.1
1904	71.4	−2.2	4.84	96	+18	324	− 39.6
1905	73.0	−0.6	0.36	83	+ 5	25	− 3.0
1906	72.1	−1.5	2.25	108	+30	900	− 45.0
1907	72.6	−1.0	1.00	86	+ 8	64	− 8.0
1908	73.9	+0.3	0.09	78	+ 0.1	....	....
1909	70.7	−2.9	8.41	96	+18	324	− 52.2
1910	73.8	+0.2	0.04	85	+ 7	49	+ 1.4
1911	74.0	+0.4	0.16	64	−14	196	− 4.8
1912	73.4	−0.2	0.04	101	+23	529	− 4.6
1913	74.5	+0.9	0.81	77	− 1	1	− 0.9
1914	74.0	+0.4	0.16	65	−13	169	− 5.2
Sum	....	....	232.64	....	....	10,179	−778.5
Mean	73.6	....	....	77.8	....	....	....

In this particular example the sums of the columns showing the squares of the departures from normal are 232.64 and 10,179 (see columns **4** and **7**). The product of these two sums equals 2,368,042.56. The square root of this product is 1,538.8. The sum of the values in column **8** is −778.5, and this divided by 1,538.8 gives a quotient of −0.51. This is the correlation coefficient, and shows the effect of the mean temperature for July upon the potato crop.

The nearer the correlation coefficient is to unity the closer the relation is between the two factors, and the nearer to zero the less the relation is. By the fact that the correlation coefficient is preceded by the minus sign it shows that the higher the temperature in July the smaller the potato crop.

It is believed that some relation is shown if the value of r is three times the probable error and that it is established without question if the coefficient is six times the probable error. The probable error is determined by the equation,

$$0.674\frac{1-r^2}{\sqrt{n}}$$

in which r is the correlation coefficient and n the number of years in the record. Substituting the above values in this equation the probable error is found to be ± 0.07.

The correlation coefficient from Table 2, −0.51, is therefore more than six times the probable error and establishes a marked relation between the mean temperature in July and the yield of potatoes in this State.

Effect of temperature by months.—A similar correlation between the potato yield in Ohio and the mean temperature of other summer and fall months has been made and is given in Table 3.

TABLE 3.—*Correlation of the mean temperature for Ohio for different periods, with the potato yield for the period 1860 to 1914.*

Periods.	Correlation coefficient.	Probable error.
	r	
May	−0.10	±0.09
June	−0.22	±0.09
July	−0.51	±0.07
August	−0.31	±0.08
September	−0.21	±0.09
October	−0.11	±0.09
June and July combined	−0.50	±0.07
July and August combined	−0.50	±0.07
June, July, and August combined	−0.49	±0.07

This indicates that while cool weather is more favorable than warm in each month considered, the temperature of either May, August, September, or October alone has very slight influence, as compared with July, upon the potato yield. Also that the temperature of June and July, July and August, or June, July, and August combined has just about the same effect as that for July alone.

An inspection of the figures showing the yield of potatoes, column **5** in Table 2, indicates an increase in the yield in recent years, and a calculation of the yield by 10-year periods shows a yield of 10 bushels per acre higher from 1900 to 1909 than the average for the whole period. Whenever there is a uniform increase or decrease in the yield of any crop it is always best, when making a correlation of this kind, to get the departure values from 10-year means. Such a correlation was made between the temperature for June and July combined and the yield of potatoes, using the 10-year departures, and the correlation coefficient was exactly the same as when the entire 55-year departures were used. Hence the longer period was used in all these calculations.

The length of time used in these correlations, the fact that the mean temperature was taken for the whole State, and the fact that the yield figures were from a crop fairly well distributed over the State, make the figures in Table 3 of marked value in showing the effect of the temperature of calendar months upon the yield of potatoes in this latitude.

Effect of rainfall upon potato yield.—On page 226 we discussed the water requirements of potatoes as shown by laboratory methods and on page 9 the actual rain that falls during the entire period of growth and development of the potato crop in different sections of the country. In Table 4 we shall show the effect of rainfall during different calendar months upon the potato yield as determined by the correlation method.

TABLE 4.—*Correlation of the rainfall for different periods with the potato yield in Ohio, for 1860 to 1914.*

Periods.	Correlation coefficient.	Probable error.
	r	
April	−0.21	±0.09
May	0.06	±0.10
June	0.10	±0.09
July	0.33	±0.08
August	0.22	±0.09
September	−0.13	±0.09
October	0.07	±0.10
July and August combined	0.37	±0.08

The low values for r in the above for May, June, September, and October indicate that the rainfall for those months alone has little effect upon the final yield of

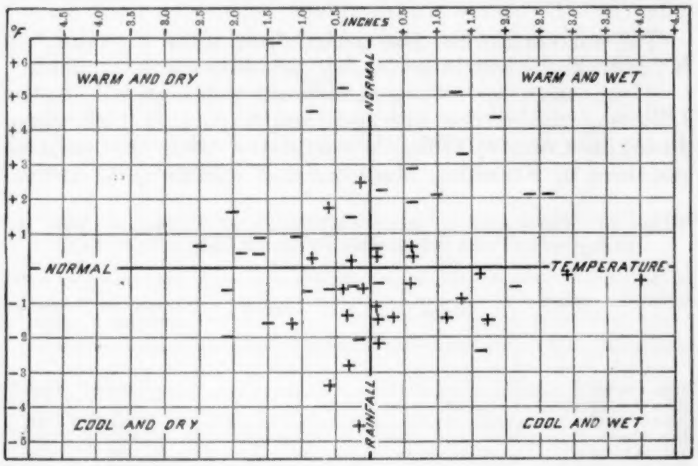

FIG. 21.—Chart showing the combined effect of temperature and rainfall during July upon the yield of potatoes in Ohio. (1860-1914, 55 years.) + Yield above normal; − yield below normal.

potatoes. April has a slight negative and August a slight positive correlation, although both are less than three times the probable error.

July, however, has a correlation coefficient four times the probable error, while that for July and August combined is nearly five times the probable error. This shows that July and July and August combined should have a moderate amount of rainfall, but it shows also that rain is not such a controlling factor as the temperature.

Combined effect of temperature and rain.—The effect of two weather factors upon the yield of a crop may be shown quickly and graphically by means of the "dot chart." This is illustrated by figures 21 and 22. In figure 21 the central horizontal line indicates the normal temperature for Ohio for the month of July. Parallel lines on either side of the normal correspond with degrees of temperature above and below the normal, respectively.

The central perpendicular line or axis of ordinates, indicates the average rainfall over Ohio in July for 55 years. The difference from the normal in inches and tenths is shown by parallel lines on either side. At the intersection of lines showing, respectively, the departure of the mean temperature and total rainfall for any particular July, a dot is placed to indicate the yield of potatoes for that year. If the yield was above the normal a plus mark is entered, and if the yield was below the normal then it is indicated by a minus sign. This makes plain the fact that warm and wet weather in July produces a bad effect upon the potato crop in practically every case. Also that warm and dry weather is generally unfavorable, although there may be a good yield if it is only moderately dry and warm. It shows also that cool weather is generally favorable, more especially if cool weather accompanies the wet weather. A cool and dry July has just as many yields above as below the normal.

In figure 22 the combined weather conditions for the months of July and August are indicated in the same manner. This emphasizes the fact that warm weather accompanied by dry weather for the whole two months is decidedly unfavorable, while good yields do sometimes result even with warm weather if there is a moderate amount of rain. Cool and wet weather for the two months is decidedly favorable.

The shifting of these plus and minus dots from one quadrant to another in these two charts indicates the

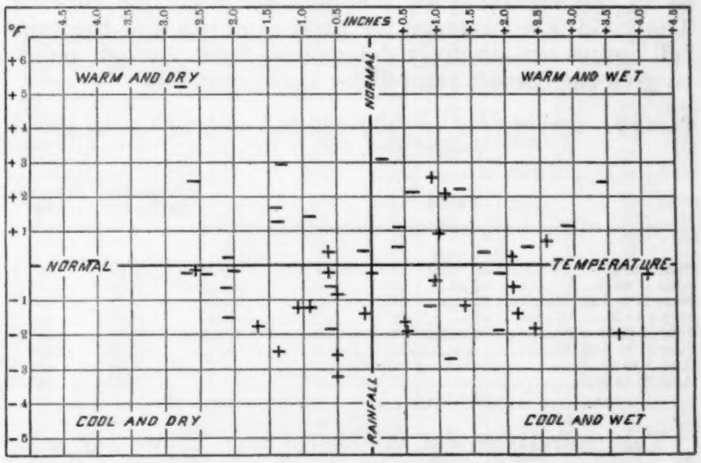

FIG. 22.—Chart showing the combined effect of temperature and rainfall during July and August upon the yield of potatoes in Ohio. (1860-1914, 55 years.) + Yield above normal; − yield below normal.

accumulative effect of certain weather conditions. A condition that may not be injurious for four weeks becomes decidedly so if continued for eight weeks.

CORRELATION FOR SHORTER PERIODS THAN A MONTH.

As the average temperature and rainfall data for the State of Ohio are compiled by calendar months the correlation just discussed was confined to months or combinations of them. It seemed desirable, however, to ascertain whether there might not be shorter periods or a different grouping of the days that would affect the potato yield. To determine this the average yield of potatoes in the three counties of Frank-

lin, Madison, and Pickaway, located in central Ohio, was computed for the period from 1891 to 1910, inclusive.

Rainfall for 10-day periods.—The rainfall for each 10 days was then averaged for some 18 different cooperative stations located in or near those counties. A correlation of the rainfall for periods of 10, 20, 30, 40, and 50 days from June 1 to August 31, with the potato yields, gives results as indicated by the following tables:

TABLE 5.—*Correlation between rainfall for 10-day periods and the yield of potatoes in central Ohio for the years 1891 to 1910.*

Period.	Correlation coefficient.	Probable error.
	r.	
June 1 to 10	0.29	±0.12
June 11 to 20	0.32	±0.12
June 21 to 30	0.16	±0.13
July 1 to 10	0.48	±0.10
July 11 to 20	−0.29	±0.12
July 21 to 31	−0.12	±0.13
Aug. 1 to 10	0.06	±0.13
Aug. 11 to 21	0.37	±0.11
Aug. 21 to 31	−0.26	±0.12

Only two of these values of r are more than three times the probable error, yet the table shows very interesting values. The first 10 days in July and the second 10-day period in August evidently should have rain to produce a good crop of potatoes, while there is a period between these days when rain seems to be detrimental.

Why is this? Is it because there are early and late crops growing at different seasons of the year? Or is there some other explanation?

While a correlation for a greater number of years might change these values slightly there is no question as to the reliability of the data for the time covered. The yield is an average for three counties and the rainfall figures are carefully determined from enough points to give the correct rainfall for these counties.

TABLE 6.—*Correlation of rainfall for 20-day periods with potato yield in central Ohio, 1891 to 1910.*

Period.	Correlation coefficient.	Probable error.
	r.	
June 1 to 20	0.48	±0.10
June 11 to 30	0.30	±0.12
June 21 to July 10	0.44	±0.11
July 1 to 20	0.03	±0.13
July 11 to 31	−0.23	±0.12
July 21 to Aug. 10	−0.08	±0.13
Aug. 1 to 20	0.29	±0.12
Aug. 11 to 31	0.22	±0.12

This correlation for 20-day periods shows the same favorable conditions for dry weather in July and the 1st of August, as was indicated in Table 5. The value of r for June 1 to 20 is almost five times the probable error, while from June 21 to July 10 it is four times the probable error. Other values of r are rather low.

TABLE 7.—*Correlation of rainfall for 30-day periods with potato yield in central Ohio, 1891 to 1910.*

Period.	Correlation coefficient.	Probable error.
	r.	
June 1 to 30	0.42	±0.11
June 11 to July 10	0.58	±0.09
June 21 to July 20	0.26	±0.12
July 1 to 31	0.002	±0.13
July 11 to August 10	−0.20	±0.13
July 21 to Aug. 20	0.19	±0.13
Aug. 1 to 31	0.11	±0.13

By this table the period from June 11 to July 10 is the most important as regards rainfall and rain is important during that time. Dry weather is most favorable from July 11 to August 10. The results from this table in particular substantiate those from Table 2.

TABLE 8.—*Correlation of rainfall for 40-day periods with potato yield in central Ohio, 1891 to 1910.*

Period.	Correlation coefficient.	Probable error.
	r.	
June 1 to July 10	0.59	±0.09
June 11 to July 20	0.35	±0.11
June 21 to July 31	0.09	±0.13
July 1 to Aug. 10	0.02	±0.13
July 11 to Aug. 20	0.02	±0.13
July 21 to Aug. 31	0.06	±0.13

Here rain is important during the period from June 1 to July 10, while there is little correlation between the rainfall, after June 21, for 40-day periods and the potato yield.

TABLE 9.—*Correlation of rainfall for 50-day periods with potato yield in central Ohio, 1891 to 1910.*

Period.	Correlation coefficient.	Probable error.
	r	
June 1 to July 20	0.44	±0.11
June 11 to July 31	0.20	±0.13
June 21 to Aug. 10	0.09	±0.13
July 1 to Aug. 20	0.17	±0.13
July 11 to Aug. 31	−0.05	±0.13

The correlation for the period from June 1 to July 20 is fairly high, but later 50-day periods are unimportant.

Temperature for 10-day periods and potato yield.—In the following tables the average temperature at Columbus, Franklin County, Ohio, is correlated with the yield of potatoes in Franklin, Madison, and Pickaway Counties:

TABLE 10.—*Correlation of mean temperature at Columbus, Ohio, for 10-day periods with potato yield in central Ohio, 1891 to 1910.*

Period.	Correlation coefficient.	Probable error.
	r	
June 1 to 10	−0.12	±0.13
June 11 to 20	−0.17	±0.13
June 21 to 30	−0.28	±0.12
July 1 to 10	−0.44	±0.11
July 11 to 20	−0.33	±0.12
July 21 to 31	−0.33	±0.12
Aug. 1 to 10	−0.23	±0.13
Aug. 11 to 20	−0.36	±0.11
Aug. 21 to 31	−0.38	±0.11

The highest correlation is −0.44 for the first 10 days of July. This value of r is just four times the probable error, and it shows plainly that potatoes in central Ohio should have cool weather at this time. By referring to Table 5 it will be seen that this same 10 days gave the highest correlation for rainfall and that wet weather is necessary.

These two tables establish the fact that cool and wet weather during the first 10 days of July is quite essential as far as central Ohio is concerned, and that the weather of this short period has a large influence upon the final yield of potatoes.

TABLE 11.—*Correlation of temperature for 20-day periods with potato yield in central Ohio, 1891 to 1910.*

Period.	Correlation coefficient.	Probable error.
	r	
June 1 to 20	−0.19	±0.13
June 11 to 30	−0.27	±0.12
June 21 to July 10	−0.61	±0.09
July 1 to 20	−0.54	±0.10
July 11 to 31	−0.41	±0.11
July 21 to Aug. 10	−0.42	±0.11
Aug. 1 to 20	−0.36	±0.11
Aug. 11 to 31	−0.43	±0.11

The 20-day period from June 21 to August 10 is the most important from a temperature point of view, and Table 6 shows that it should be wet as well as cool. The value of r for July 1 to 20 is almost six times the probable error.

TABLE 12.—*Correlation of temperature for 30-day periods with potato yield in central Ohio, 1891 to 1910.*

Period.	Correlation coefficient.	Probable error.
	r.	
June 1 to 30	−0.33	±0.12
June 11 to July 10	−0.53	±0.10
June 21 to July 20	−0.61	±0.09
July 1 to 31	−0.57	±0.09
July 11 to Aug. 10	−0.51	±0.10
July 21 to Aug. 20	−0.49	±0.10
Aug. 1 to 31	−0.35	±0.11

All values of r are three times the probable error and that for the two periods June 21–July 20 and July 1–31 is more than six times the probable error. These values of r for the three periods covering each of the full months of June, July, and August, comparing so closely with those for the State of Ohio for a much longer period as seen in Table 3 proves that the results from Tables 10 to 14, which are for a much shorter period and smaller area, are accurate.

TABLE 13.—*Correlation of temperature for 40-day periods with potato yield in central Ohio, 1891 to 1910.*

Period.	Correlation coefficient.	Probable error.
	r.	
June 1 to July 10	−0.58	±0.09
June 11 to July 20	−0.58	±0.09
June 21 to July 31	−0.62	±0.09
July 1 to Aug. 10	−0.63	±0.09
July 11 to Aug. 20	−0.54	±0.10
July 21 to Aug. 31	−0.51	±0.10

These values of r are all high and are about what one would expect from preceding tables.

TABLE 14.—*Correlation of temperature for 50-day periods with potato yield in central Ohio, 1891 to 1910.*

Period.	Correlation coefficient.	Probable error.
	r.	
June 1 to July 20	−0.58	±0.09
June 11 to July 31	−0.54	±0.10
June 21 to Aug. 10	−0.65	±0.08
July 1 to Aug. 20	−0.67	±0.08
July 11 to Aug. 31	−0.52	±0.10

Table 14 gives very little of value over Table 13. A study of the weather that is prevailing during any season with the requirements as shown by the preceding tables, would enable any potato grower to judge whether he may expect a good or a poor crop. If he will extend his observation over the county or the state or over an even larger district, he can make a good estimate of what the general yield will be.

WEATHER EFFECTS DURING DIFFERENT PERIODS OF DEVELOPMENT OF POTATOES.

Mr. Thomas Mikesell of Wauseon, Ohio, in Fulton County, has kept a very complete record [1] of phenological dates and data since 1883, and in Table 15 these data are given for early potatoes. It will be seen that the date potatoes are planted each year, is given as well as the date that the plant appears above the ground, the date in blossom, the date they are ready for use, and the date ripe.

In addition Mr. Mikesell recorded the potato yield in percentages of a "good crop" and the quality of the crop. As he is a very careful observer the data are reliable. Mr. Mikesell has compiled the same data for late potatoes and from his tables it appears that the average date for planting late potatoes is May 19, the average date that they appear above the ground, May 31, average date in bloom, July 7, and the average date ripe, September 8.

TABLE 15.—*Phenological dates and data for growth of early potatoes at Wauseon, Ohio, 1883 to 1912, by Thomas Mikesell.*

[Lat., 41° 35′ N.; long., 84° 07′ E.; alt., 780 feet A. M. S. L.]

Year.	Date planted.	Date above ground.	Date in bloom.	Date ready for use.	Date ripe.	Per cent of good crop.	Quality of crop.
1883*	Apr. 12	May 8	June 10	June 30	Aug. 20	....	....
1884	21	14	18	July 2	July 30	....	....
1885	23	19	25	9	31	....	....
1886	22	9	12	June 24	20	85	Good.
1887	26	11	18	30	25	100	Do.
1888	23	18	20	July 10	Aug. 8	70	Do.
1889	22	11	21	June 27	15	95	Do.
1890	25	13	14	22	July 28	50	Fair.
1891	24	11	17	June 29	Aug. 7	95	Good.
1892	28	14	20	July 1	15	90	Do.
1893	24	15	16	5	1	60	Do.
1894	17	1	8	June 25	1	60	Do.
1895	27	7	17	July 10	20	60	Do.
1896	May 1	12	14	June 19	8	100	Do.
1897	6	20	25	July 10	July 28	60	Do.
1898	21	30	29	30	Aug. 20	....	....
1899	Apr. 25	6	10	June 20	5	80	Good.
1900	28	....	....	....	....	....	....
1901	17	....	June 20	....	....	....	....
1902	21	....	8	June 23	....	....	....
1903	....	....	May 28	....	....	....	....
1904	May 5	May 17	June 20	....	Sept. 12	75	Good.
1905	4	10	6	June 27	Aug. 25	80	Do.
1906	Apr. 24	10	11	July 3	Sept. 1	80	Do.
1907	May 4	14	18	7	Aug. 20	45	Do.
1908	Apr. 22	10	8	12	1	50	Do.
1909	May 5	12	8	3	5	60	Do.
1910	Apr. 8	8	18	10	20	85	Do.
1911	May 4	25	24	8	July 28	40	Fair.
1912	Apr. 16	9	16	June 28	25	75	Good.
Average	Apr. 26	May 13	June 15	July 2	Aug. 9	72	....

* Data for the years 1883 to 1901, inclusive, apply to Mr. Mikesell's own farm; data for 1902 to 1912 apply to certain nearby fields, the same field being used for the entire season.

Weather constants and development of potatoes.—At the same time that Mr. Mikesell kept the data shown in Table 15 he recorded the daily temperature and rainfall from reliable and well-exposed instruments. We have therefore tabulated the total number of days, total "effective temperature," and total rainfall for each year in Table 16. Unfortunately most of the data for crop develop-

[1] See Monthly Weather Review Supplement No. 2. Washington, D. C., 1915.

ment were not observed during the years 1900 to 1903; hence the constants data are omitted for those years.

It will be seen that Table 16 contains the thermal and rainfall constants and the total number of days between each period of development as noted in Table 15, as well as the totals of these factors from planting to ripening of early potatoes. The highest and lowest total values are printed in distinctive type.

The total number of days from planting to ripening will be found to vary from 83 to 134, the total "effective temperature" from 1,908 degrees to 3,149 degrees, and the total rainfall from 5.5 inches to 23.9 inches. The average number of days is 106, average thermal constant 2,414 degrees, and the total average rainfall 12.6 inches. There seems to be no very close relation between the totals of these three different constants for different years. The heat necessary to develop the plant seems to be the most constant from year to year.

TABLE 16.—*Constants during the growth of potatoes at Wauseon, Fulton County, Ohio, 1883 to 1912.*

Year.	Time.					Total effective temperature.				Total rainfall.			
	From planting to above ground.	From above ground to bloom.	From above ground to ready for use.	From bloom to ripe.	From planting to ripe.	From planting to above ground.	From above ground to bloom.	From bloom to ripe.	From planting to ripe.	From planting to above ground.	From above ground to bloom.	From bloom to ripe.	From planting to ripe.
	Days	*Days*	*Days*	*Days*	*Days*	°*F.*	°*F.*	°*F.*	°*F.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*
1883	26	33	53	71	130	215	502	1,737	2,454	1.0	6.7	10.8	18.5
1884	23	35	50	42	100	272	764	1,163	2,199	2.6	2.9	5.0	10.5
1885	26	37	51	36	99	244	836	1,090	2,170	3.4	6.9	3.2	13.5
1886	17	34	46	38	89	242	630	1,036	*1,908*	1.4	2.3	1.8	*5.5*
1887	15	38	50	37	90	243	906	1,311	2,460	1.3	4.7	4.4	10.4
1888	25	33	53	47	105	269	731	1,418	2,418	2.0	2.3	4.0	8.3
1889	19	41	47	55	115	273	707	1,455	2,435	0.1	11.4	6.8	18.3
1890	18	32	40	44	94	143	680	1,177	2,000	5.5	1.6	4.0	11.1
1891	17	37	49	51	105	200	720	1,349	2,269	0.8	3.2	4.4	8.4
1892	16	37	48	56	109	171	746	1,617	2,534	7.4	10.4	6.1	**23.9**
1893	21	32	51	46	99	153	675	1,378	2,206	5.2	3.9	5.2	14.3
1894	14	38	55	54	106	183	553	1,738	2,474	2.4	4.0	3.1	9.5
1895	10	41	64	64	115	240	868	1,976	3,084	1.2	1.8	2.5	*5.5*
1896	11	33	38	55	99	285	749	1,617	2,651	0.7	4.9	13.7	19.3
1897	14	36	51	33	*83*	234	678	1,031	1,943	2.0	3.3	4.6	9.9
1898	9	30	61	52	91	188	801	1,570	2,559	0.7	3.6	6.7	11.0
1899	11	35	45	56	102	275	729	1,653	2,647	1.0	4.1	5.2	10.3
1900	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1901	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1902	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1903	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1904	12	34	.....	83	129	148	687	2,075	2,910	0.6	3.3	8.0	11.9
1905	6	27	48	80	114	64	422	2,178	2,664	1.0	6.8	9.5	17.3
1906	16	32	54	82	130	151	718	2,280	**3,149**	0.9	3.0	10.2	14.1
1907	10	35	54	63	108	103	480	1,717	2,400	0.5	5.9	6.3	12.7
1908	18	29	63	54	101	124	665	1,507	2,296	1.8	4.9	7.7	14.4
1909	7	27	52	58	92	76	495	1,532	2,103	2.4	3.5	7.6	13.5
1910	30	41	63	63	**134**	202	593	1,841	2,636	5.8	2.6	6.4	14.8
1911	21	30	44	34	85	505	802	963	2,270	0.5	3.9	6.5	10.9
1912	23	38	50	30	100	223	723	1,062	2,008	1.7	6.1	1.7	9.5
Average	**17**	**34**	**50**	**55**	**106**	**209**	**687**	**1,518**	**2,414**	**2.1**	**4.5**	**6.0**	**12.6**

A correlation of constants and yield.—A tabular correlation between the thermal constants and the yield of potatoes as reported by Mr. Mikesell is given in Table 17.

TABLE 17.—*Correlation between thermal constants and potato yield, Wauseon, Ohio, 1883 to 1912.*

Period.	Correlation coefficient.
	r.
From date of planting to date above ground	0.03
From date above ground to date of bloom	0.24
From date of bloom to date ripe	0.16
From date planted to date ripe	0.25
For 10 days before blooming	0.17
For 10 days after blooming	−0.30

The most important value of r in this table is that for the 10 days after blooming when cool weather is desirable. This, however, is not over three times the probable error, so that too much weight must not be given to the result.

Unfortunately, we do not have the blooming dates for central Ohio; but if the time from planting to blooming for late potatoes is the same in central Ohio as at Wauseon, the 10-day after-blooming period would agree closely with some of the highest 10-day correlations, as shown in Table 10. This, after taking into account the difference in date of planting between Wauseon and Columbus.

TABLE 18.—*Correlation between rainfall and potato yield, Wauseon, Ohio, 1883 to 1912.*

Period.	Correlation coefficient.
	r
For 10 days before planting	0.02
From date planted to date above ground	−0.06
From date above ground to date in bloom	0.33
From date in bloom to date ripe	0.18
For 10 days before blooming	0.09
For 10 days after blooming	−0.07

The only value of r to be considered in Table 17 is for the period between the date that potatoes come up and the date that they are in bloom.

If the time between the date of planting and the dates that they appear above the ground and the date they are in bloom is the same for late potatoes at Columbus as at Wauseon, Ohio, then the time for the highest value of r in Table 18 agrees very closely with the next to the highest value for r in Table 6 and is not far from the time of the highest in Table 7.

The cumulative evidence is that the most important time for rainfall for potatoes, so far as these correlations show, is before blooming.

In Colorado it was found that with thorough cultivation, potatoes planted the first of May needed irrigation seldom until July. Also that one should not irrigate after August 10, so as to give 50 to 60 days for ripening in dry earth.

In Wisconsin it was found that one of the secrets of irrigation of potatoes was not to irrigate until after the young tubers had set. When irrigated immediately before setting a greater number of potatoes were formed than the plant can properly support and mature. In Utah it was found that increased irrigation increased the starch content and decreased the protein content of potatoes.

In 1914 a yield of 110 bushels of potatoes was produced on one-eighth of an acre of land in Fremont County, Idaho. This is at the rate of 880 bushels per acre and is reported to be the highest yield ever produced in this country. The date of planting was not given in the article that came under the observation of the writer, but the potatoes came up about the first of June. The first irrigation was given July 20 and the last September 7. By October 15 the crop had matured, and on October 20 it was harvested.

A study of the preceding tables will show the best time during the growth of the potato plant to apply water in irrigation, and also whether a given rain can be used to best advantage by the plant.

OTHER INVESTIGATIONS.

In Portage County, Ohio.—In the spring of 1914 Mr. H. A. Stevens, a student in agricultural meteorology at the Ohio State University, investigated the relation between the weather and the yield of potatoes in Portage county. The period covered was from 1884 to 1913.

Mr. Stevens states that while Portage County has a wide variety of soils most of the potatoes are grown on sandy lands. Also that most of the commercial growers raise late potatoes and plant them very late, although they are practically all in the ground by July 1. Portage County is in the best potato-growing district of northeastern Ohio.

Mr. Stevens found little or no correlation between the yield of potatoes and either the temperature or the rainfall of June, July, or September. During the month of August, however, he found rainfall and high temperature both to be favorable. The correlation coefficient for the rainfall for August and the yield of potatoes was 0.26, and that for the temperature and the yield was 0.44. This value of r for the temperature is six times the probable error and for rainfall slightly less than three times the probable error.

The present writer has since correlated temperature and rainfall with the potato yield in Portage County, covering a period of 54 years, without finding a high correlation between the temperature of any particular month or group of months and the yield. Table 19 shows the results of this calculation.

TABLE 19.—*Correlation of the average temperature with potato yield in Portage County, Ohio, 1860 to 1913.*

Period.	Correlation coefficient.
	r.
April	0.13
May	0.06
June	0.19
July	−0.14
August	0.14
September	−0.22
October	−0.02
June and July combined	−0.04
July and August combined	−0.12
June and July with July reversed	0.20
July and August with July reversed	0.22

Inasmuch as the potatoes are planted so late one would expect no correlation between the temperature of either April, May, or June, and the yield. The plus value of r for August, even though slight, in this correlation and the higher value in Mr. Steven's calculation are not what we would expect from other tables.

At Wauseon in northwestern Ohio the average number of days between planting and blooming of late potatoes is 49. If it takes about the same length of time in Portage County from planting to blooming this would bring the critical period for temperature sometime in August when the average temperature for the whole month would cover the time before blooming when warm weather seems desirable, and after blooming when it should be cool. This would in part explain the failure to find a correlation between the average temperature for a complete month and the yield.

TABLE 20.—*Correlation of the rainfall with potato yield in Portage County, Ohio, 1860 to 1913.*

Period.	Correlation coefficient.
	r.
June	−0.23
July	0.06
August	0.38
September	−0.03

In this table there is a fairly high value of r for the August rainfall.

Correlation in Licking County.—In the spring of 1914 Mr. Paul Geiger, another student in agricultural meteorology at the Ohio State University correlated the weather with potato yield in Licking County in central Ohio. His results are given in Table 21.

TABLE 21.—*Correlation of the temperature and the rainfall with the yield of potatoes in Licking County, Ohio, 1884 to 1913.*

Period.	Correlation coefficient.	
	Temperature.	Rainfall.
	r.	r.
May	−0.02	0.02
June	−0.48	0.38
July	−0.35	0.21
August	−0.27	−0.34
September	−0.02	−0.17
October	−0.04	−0.14
June and July combined	−0.59	0.41
July and August combined	−0.87	* 0.18
August and September combined	−0.27	−0.12
June, July, and August	−0.55	0.35
July, August, and September	−0.38	* −0.24

* Departure sign for July reversed.

In the calculation for Table 21 Mr. Geiger used 10-year means in both yield and weather data before getting the departure values, because the yield of potatoes has increased in recent years. In the calculations in Table 22 the present writer has covered a longer period and has obtained the departure from a mean for the whole 54 years.

TABLE 22.—*Correlation of the temperature with the potato yield in Licking County, Ohio, 1860 to 1913.*

Period.	Correlation coefficient.
	r.
April	−0.01
May	0.06
June	−0.29
July	−0.36
August	−0.28
September	−0.23
October	−0.15
June and July combined	−0.44
July and August combined	−0.44
August and September combined	−0.15

The value of r for June and July combined and for July and August combined is almost six times the probable error and agrees very closely with the same periods in Table 3 for the whole State. These last tables merely emphasize the facts brought out in the earlier ones and add to the weight of evidence that cool summers produce the best yields of potatoes in this latitude.

Studies in Michigan.—During the present semester at the Ohio State University, Mr. Edward B. Scott, a special student in agricultural meteorology, is studying the effect of the weather upon the potato yield in the State of Michigan. His period covers from 1887 to 1914, inclusive, and the data are for the whole State.

His work is not complete at time of writing, but for the month of July he finds the value of r in a correlation between temperature and yield to be −0.543, or five times the probable error. For the month of August it is 0.05, for September 0.15, and for July and August combined −0.345.

This value of r for July agrees with the studies in Ohio. Studies similar to these should be made in other States, particularly those where potatoes are grown so extensively as in northern New England and New York.

By a comparison of the facts given in the preceding pages with the mean monthy temperature and monthly distribution of rainfall charts, as published by the United States Weather Bureau, one can determine whether any given locality is favorable for potato culture. One can determine also when they should be planted so as to bring wet or dry periods in proper sequence in the growth and development of the potato plant.

SEED POTATOES.

It is customary to consider northern-grown potatoes more suitable for planting than those grown in the neighborhood or farther south. This matter is discussed in the Ohio Agricultural Experiment Station Bulletin 218 and the conclusion is reached that far northern-grown potato seed is not superior to Ohio-grown seed, if our home-grown seed is well preserved.

The following is quoted from that bulletin: "The reason that northern-grown stock has come to be noted for its superiority for a more southern latitude is because the seed is wintered in a lower degree of temperature in the more northern sections; it is kept sound and hard, crisp, fresh, and dormant and comes down to us at or just previous to planting time in this most desirable condition."

Farmers' Bulletin 386 states that uniform growth without check in development produces seed potatoes of high vitality. This bulletin states also that there is danger of using varieties that set a larger number of tubers than can be developed unless moisture is plentiful at just the right time.

Climate and weather should be studied.—This raises the point that the seasonal distribution of rainfall must be studied to see that it does come at the right period in the growth of the potato plant. Before planting the seed the weather of the period when it was completing its development should be carefully studied to see that the plant had the proper distribution of heat and moisture to enable it to have "uniform growth without check in development."

Are the best seed potatoes immature?—The question has been raised as to whether northern-grown seed is not better because the potatoes were dug before they were quite ripe, and thus keep "more crisp, fresh, and dormant," and can be shipped south in this most desirable condition. This matter should receive the attention of experiment station investigators.

DISEASES OF POTATO PLANTS.

The foliage of the potato plant is particularly subject to diseases which are affected by weather conditions to a marked degree.

Early blight, tip-burn, and the *Fusarium* dry-rot are dry-weather diseases while late blight develops in wet and cool weather in some districts and in wet and hot weather in others. Sun scald occurs when bright and hot weather follows suddenly a moist and cloudy period.

Other diseases such as brown-rot, rosette, potato wilt, and dry end rot affect the foliage in particular sections of the country, and it seems probable that a further study of these will show that most of them are more or less severe under certain weather conditions.

The early blight of the foliage, due to the attacks of the fungus, *Alternaria solani*, develops most rapidly in dry weather and seems to be rather characteristic of dry warm soils.

Tip-burn is a physiological disease which may follow a long period of hot, dry weather and is really a scorching of the tips of the leaves due to lack of moisture. This disease is most apt to occur after blooming.

The dry-rot of potatoes, which is a well-known storage trouble, has been found to be due to a fungus of the genus *Fusarium* variously designated as *Fusarium oxysporum* and *Fusarium solani*. This disease is manifest in the field with most varieties of potatoes by a partial wilting, an inward and upward turning of the leaves, and a changing to a sickly yellow. It seems quite apparent that drought hastens the yellowing symptoms of the disease, whatever effect this has upon the activity of the fungus causing the disease.

Late blight.—The so-called "late blight" of potatoes is the most serious of all potato diseases and is due to the fungus *Phytophthora infestans*. The potato rot resulting from this disease caused very great loss in eastern North America in 1842, 1845, and 1874, and there was a general outbreak in New England and New York in 1901, 1902, and 1903. In 1845 the disease spread through Great Britain, Ireland, and Belgium, and the terrible Irish famine of that year was due to the almost total loss of the potato crop of Ireland from this disease during the preceding summer.

This disease is undoubtedly favored by moist weather. Rainfall apparently has much to do with the spread of the disease, particularly if heavy rain is followed by cloudy weather and still air, when the moisture would cling to the leaves for a long time. If the rainfall is followed by clear skies and sufficient wind to quickly evaporate the moisture from the potato leaves, then the disease would be checked.

Effect of temperature on late blight.—Writers in some parts of the country state that late blight will develop with a spell of *warm*, moist, "muggy" weather, while in other sections it will be noted that a serious outbreak of late blight has followed a period of *cool*, moist weather.

In Bulletin 245 of the United States Bureau of Plant Industry the following statement is made as to the effect of temperature upon *Phytophthora infestans:*

> Exposing test-tube cultures for 10 minutes at temperatures up to 40° C. did not prevent the later development of the fungus; beyond this temperature inhibition resulted. Where cultures were held at constant temperatures the best growths resulted between 16° and 19°C. (60.8° and 66.2°F.). Below 16°C. the growth was slower, and below 5°C. (41°F.) it was wholly inhibited. At and above 23°C. (73.4°F.) the growth was inhibited, with no sporulation above 25°C. (77°F.) and no vegetative growth at or above 30°C. (86°F.).

Prof. A. D. Selby, in the Ohio Naturalist for February, 1907, quoting from Scribner, says: "A temperature ranging from 65° to 75°F. produces conditions favorable for the disease"; and quoting from Galloway: "A daily mean or normal temperature of from 72° to 74°F. for any considerable time, accompanied by moist weather, furnishes the best conditions for the spread of the disease."

It should be noted that while the authors quoted above do not agree as to the most favorable temperatures for the spread of late blight, in one instance the writer refers to tests made under *constant* temperatures while the other two refer to *mean daily* temperatures, when the temperature would be higher than the optimum in the daytime and lower in the nighttime.

It is probable, therefore, that the most favorable open-air temperature condition is when the mean daily temperature is between 70° and 74°F. Also that the development of the disease is checked if the mean daily temperature is above 75° F. for a few days, and that the spores are killed at a temperature of 77° to 80° F.

Temperature terms are relative.—In figure 23 there has been entered the highest mean daily temperature during the warmest part of the year at each of the Weather Bureau stations. Isothermal lines have been drawn for each 5 degrees.

This chart shows that in extreme northern parts of the country and in the higher parts of the Rocky Mountain States the mean summer temperature is generally too low for the best development of late blight in potatoes and that practically all of the central and southern districts are too warm for the disease to get a foothold.

This makes plain also why in Maine late blight is a disease of "warm" moist weather, while in Ohio it is spoken of as a disease of "cool" moist summers.

to cause serious damage, so that even with a cool and moist summer which we have found favorable for the growth of potatoes there might result a very poor yield, due to loss by late blight. Then one warm and dry season, although unfavorable for the yield of potatoes, would yet kill out the *Phytophthora* so effectually that it would take another series of cool years for it to become again established.

CONCLUSION.

This paper is submitted, not with the feeling that it is without criticism or entirely without error or that the last word has been said upon the subject of the effect of weather upon the yield of potatoes—indeed, there are

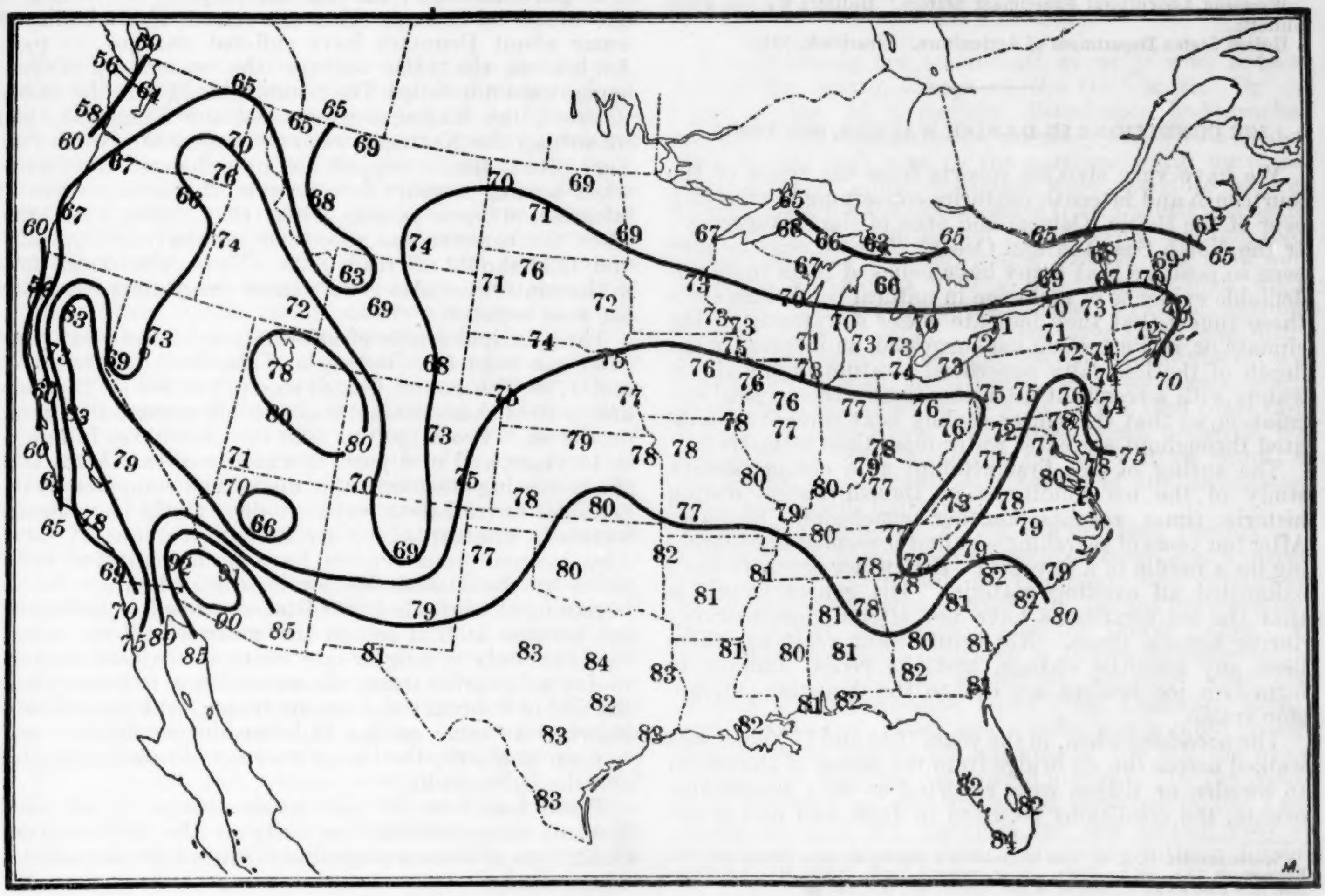

FIG. 23.—Highest mean daily temperature (°F.) during the warmest part of the season.

An inspection of the yearly temperature records would show that north of this normal temperature line of 70° there are seasons or periods when the temperature is high enough to cause an outbreak of the late blight, and that even south of the line of 75° a season might be cool enough to cause loss to the potato crop. The critical district would be along the line of 70°, as shown on this chart.

It must be remembered that in the southern portion of this critical area it would take more than a few weeks of cool weather to develop the disease and that even one cool season would hardly do it. But that with a series of cool summers it might become sufficiently developed

several different lines of investigation that it suggests and that might well be carried out—but rather with the hope that its presentation may encourage others to delve into this almost completely neglected but wonderfully interesting and thoroughly economical and important field of science. The United States Weather Bureau, at its regular and cooperative stations, has accumulated a vast amount of meteorological and climatological data; the various State boards of agriculture and the United States Department of Agriculture have compiled records of crop production for a long period of years. It only remains for plodding investigators to put these data together and develop a live and practical *agricultural meteorology*.

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ICE CONDITIONS IN DANISH WATERS, 690-1860.[1]

We have very striking reports from the times of the fourteenth and fifteenth centuries concerning the freezing over of the Baltic (Ostsee) and even of the "Skagerrak" or the North Sea (German Ocean). These reports have been so positive that many have believed them to be undeniable evidence of a change in natural conditions since those times; that they indicate either a warming of the climate or, as Pettersson has suggested, an increase in the depth of the less salty superficial stratum of the Baltic waters with a resultant intensification in the vertical circulation, so that the winter cooling is at present distributed throughout a greater water mass than formerly.

The author of this first attempt at a comprehensive study of the ice conditions in Danish waters during historic times reaches another conclusion, however. After ten years of searching—at first it seemed like searching for a needle in a haystack—the author seems to have exhausted all existing material. His general result is that the ice conditions have not altered demonstrably during historic times. Not until recent years has there been any essential change, and the recent failures to form firm ice bridges are due to the disturbing steamship traffic.

The occasions when, in the years 1635 and 1709, persons walked across the ice bridge from the island of Bornholm to Sweden or Rügen were reported as very remarkable events; the conditions recurred in 1838 and had it not been for the steamboats, would have returned in 1893. The reported earlier "lively travel" on the ice may be compared with similar reports in recent years, e. g.—the report by Ritzau's Bureau on March 18, 1909, concerning traffic across the "Kleinen Belt" (strait between Schleswig-Holstein and the Island of Fünen), upon investigation turned out to have been based upon the fact that two men dared to walk across and a number of children played near the shore. One is all the more justified in assuming similar exaggerations in earlier times also, since among the reports are some demonstrably false ones. General statements such as "the Baltic was frozen over," "the Black Sea was frozen over," may with certainty be interpreted as applying to individual bays only.

In part, however, this unreliability of the records is due to special causes. Thus the names of the bodies of water about Denmark have suffered changes, in part. As late as the 18th century the waters off Copenhagen were not called The Sound [Sund], but the Baltic (Ostsee), the Kattegat was called the Skagerrak, and sometimes the Kattegat was even called the North Sea. Very often, also, a copyist has interchanged the figures when writing a year; for example, different sources of information have written 1292, 1294, 1296, and 1269, when the correct year was 1296; similarly, 1320, 1323, and 1333 should all read 1323. That New Years falls in the wintertime also often causes uncertainty regarding the year number.

The principal source of information for the years since 1750 has been the Berlingske Tidende. Between 1750 and 1799 The Sound [Sund] was full of ice in 29 years, and in 10 of those years it was possible to cross the [Sund] on the ice. From 1800 to 1849 the [Sund] was full of ice in 19 years, and in 9 years it was crossable. After 1850 the increasing steamer traffic made such comparisons impossible; nevertheless even to-day traffic on Danish waters is interrupted by ice in one year out of three. Also ice-conditions reports have been instituted seven times by the Danish Meteorological Institute. At the beginning of winter heavy frosts have no effect in forming ice, because at that season the water is still too warm; ice forms only in long or late winters. In hard winters, to-day as in earlier times, the waters begin to freeze about the first of February and remain frozen until the middle of March. As early as the 16th century navigation used to open in March, the buoys were set out about March 1 and the lights re-lit.

There has been no noticeable change in all these features since certainly as early as the 15th century. Conditions of these waters since 1860 will be discussed in a later study.

[1] **Speerschneider, C. J. H.** Om isforholdene i Danske farvande Aarene 690-1860. Kopenhagen, 1915. 141 p. Plate. (Dans. meteorol. Instit., Public., Mitt. 2.) *Translated from* abstract by V. Köppen in Met. Ztschr. apr. 1915, **32**: 188-9.)

SECTION III.—FORECASTS.

FORECASTS AND WARNINGS FOR MAY, 1915.

By H. C. FRANKENFIELD, Professor of Meteorology.

[Dated: Weather Bureau, Washington, June 9, 1915.]

GENERAL PRESSURE DISTRIBUTION OVER THE UNITED STATES AND CANADA, INCLUDING THE SANDWICH AND ALEUTIAN ISLANDS, ALASKA, AND THE WESTERN PORTION OF THE MIDDLE ATLANTIC OCEAN.

Pressure was low at Honolulu during the greater portion of the month, especially during the first nine days, with the greatest depression from the 4th to 6th, inclusive. Over the Aleutian Islands high pressure prevailed until the 12th, and low pressure thereafter until the 26th, at which time there was a rise for three days. The extremes, however, were not marked. Over northern Alaska high pressure prevailed almost continuously throughout the month with the principal crest on the 5th, and somewhat lesser ones on the 12th and 16th. Over southern Alaska conditions were reversed to a certain extent and low pressure was the rule after the first five days of the month, this condition extending to a greater or less extent eastward over Alberta. From Manitoba eastward through the Province of Ontario low pressure prevailed generally during the first decade of the month with a minimum on the 7th and 8th, but afterwards moderately high pressure ruled. From the Province of Quebec eastward low pressure prevailed generally, except for brief intervals at the end of each decade of the month.

Pressure over the United States was characterized by persistent low pressure in the Plateau region and the Atlantic and Gulf States, with the same brief interruptions of moderately high pressure that characterized the distribution over northeastern Canada. Over the great basin of the country pressure was low until the 8th, and more or less irregular after that time. Over the western Atlantic Ocean low pressure predominated largely.

The persistent low pressure over much of the United States and the absence of well-defined high areas combined to make the month one of much uncertainty so far as the various special warnings were concerned. Quite often a certain pressure distribution would indicate the necessity of storm warnings on the Lakes, or the Ocean, or the Gulf coasts, but 12 hours later there would be such an entire change in distribution as to necessitate the lowering of the warnings. No severe storms occurred, but there were occasional moderately high winds of brief duration for many of which warnings were ordered, but without satisfactory results, because, as stated before, the rapid change in pressure conditions would necessitate their lowering within 12 hours.

The same difficulty frequently attended the forecasting of frosts over the northern sections, as the rapid shift of pressure conditions would sometimes result in rising pressure with clearing weather and attendant frosts within a few hours, while at other times high pressure with low temperatures that indicated the occurrence of frost would be rapidly followed by a decided fall in pressure with increased cloudiness, thereby preventing the occurrence of frost for which warnings had been ordered. The principal frost of the month was not forecast because the previous conditions over the territory affected indicated cloudy weather and rain, whereas exactly the reverse occurred owing to the rapid 12-hour movement of a low-pressure area in the northeast and the equally rapid development of a cold high area in its rear.

STORM WARNINGS.

Comparatively few small-craft warnings were ordered during the month, except on the Gulf coast. On the night of the 2d a western disturbance had reached western Iowa with increased intensity and with a moderately strong high area to the northeastward; northeast and southeast storm warnings were therefore ordered at 9.45 p. m. for the Great Lakes from Duluth to Toledo, but pressure distribution on the following morning indicated that they were no longer needed, and they were therefore lowered at 9:30 a. m., with no high winds reported, except a moderate northeast gale on extreme western Lake Superior. On the evening of the 6th a pronounced disturbance from the extreme southwest was central over southeast Texas, and southeast storm warnings were ordered at 10 p. m. on the Gulf coast from Mobile to Cedar Keys. Only fresh winds occurred, but the warnings were displayed for the full 24 hours, as the future development and course of the disturbance were not clearly indicated.

On the morning of the 7th the northern portion of a southwestern disturbance was central over Lake Superior with greatly increased development, and southwest warnings were ordered at 9:30 a. m. for the northern and eastern upper Lake region and the Lower Lakes. As special observations indicated a future increase in intensity of the storm, southwest warnings were also ordered on the Atlantic coast from Delaware Breakwater to Boston. Here again there was a rapid change in conditions, and on the morning of the 8th the warnings on the Atlantic coast were lowered. In the meantime, however, strong winds had occurred in the Lake region, so that the warnings for this section may be considered as having been justified. Nothing further developed until the 11th, when a disturbance from the mouth of the Rio Grande was central over extreme southwestern Alabama. There were indications of further development to the northeastward where pressure was high, and southeast storm warnings were therefore ordered at 9:45 a. m. from Pensacola to Cedar Keys and northeast warnings on the Atlantic coast from Tybee Island to Hatteras. Some high winds occurred on the northwest Florida coast, but the storm failed to develop to the northeastward and all warnings were ordered down at 9 p. m. of the 11th.

On the morning of the 14th middle Plateau depression was central over northwestern Nebraska. Special observations at 1 p. m. indicated a further increase in intensity, and, as there was a strong gradient to the northeastward, northeast storm warnings were ordered at 3 p. m. over western Lake Superior and along the western shore of northern Lake Michigan. There was no further development, however, and at 9 p. m. the

warnings were ordered down, except on extreme western Lake Superior. On the morning of the 15th there was a redevelopment of the western disturbance, and it was then central over northwestern Iowa. Special observations were obtained at 1 p. m., and as conditions at that time indicated the further display of warnings, northeast warnings were therefore ordered on Lake Superior from Duluth to Ashland. This warning was verified, Duluth reporting a maximum velocity of 44 miles from the northeast during the night of the 15–16th. Warnings were also ordered on the morning of the 16th for the eastern shore of northern Lake Michigan and for Lake Huron as far south as Tawas Point. This warning was ordered because a secondary disturbance still persisted over southwest Wisconsin, and during the day strong winds occurred over the portions of the district covered by the warnings. They were, however, ordered down at 9 p. m., as the storm had passed rapidly to the eastward.

Special observations at 1 p. m. of the 18th indicated the movement of a middle Plateau low toward the Texas coast, and southeast warnings were therefore ordered for that vicinity, and extended at 10:30 p. m. eastward along the Gulf coast to Apalachicola. Strong winds occurred on the Texas coast, but none to the eastward, and at 3 p. m. of the 19th the warnings on the coast from Louisiana eastward were lowered. On the morning of the 21st another disturbance from the far West was central over northeast Iowa with well-defined formation, and northeast warnings were ordered on Lake Superior and southeast warnings on the western shore of northern Lake Michigan. Small-craft warnings were also ordered at the same time for the balance of Lake Michigan, except Chicago, and for Lake Huron. At 3 p. m. of the same date southwest warnings were ordered from Port Huron to Oswego, but by the following morning the storm conditions had practically disappeared, and the warnings were lowered at 9 a. m. Over the Upper Lakes, however, moderately strong winds had occurred, but they were of very brief duration. No further warnings were ordered until the 27th, when a strong gradient, caused by marked high pressure over the Lake region, indicated increasing northeast winds on the south Atlantic coast, and warnings were therefore ordered at 11:30 a. m. from Fort Monroe to Savannah. Quite a strong northeast gale prevailed for a short time, but at 9 p. m. the warnings were lowered, as pressure had fallen rapidly and decidedly to the northward.

FROST WARNINGS.

Frost warnings were necessary over some portions of the country during 24 days of the month, and, as a rule, the frosts occurred as forecasted, the only notable failure having been the one of May 27 in the Upper Lake Region and interior New York. At different times during the first 20 days of the month warnings of freezing temperature were necessary for portions of the West, especially the Plains States and the central Rocky Mountain Region, and temperatures as low as 22° occurred over the latter district, accompanied by heavy snow that extended for a considerable distance along the eastern slope of the mountains. The last general frost warning was issued on the 29th for the North Pacific States, while on the 30th and 31st warnings were issued for the cranberry districts of Wisconsin, New England, and New Jersey.

SECTION IV.—RIVERS AND FLOODS.

RIVERS AND FLOODS, MAY, 1915.

By ALFRED J. HENRY, Professor of Meteorology, in charge of River and Flood Division.

[Dated: Washington, D. C., June 25, 1915.]

The last decade of May, 1915, was generally a rainy period over the greater portions of the country, with heavy to excessive rainfalls over the Middle and Lower Mississippi Valley, the Gulf and South Atlantic States, and the California Valley. Owing to the protracted dry weather previous, however, the resulting river stages were somewhat lower than ordinarily obtain in consequence of like amounts of rainfall.

Mississippi River.—No material rises were caused in the Mississippi, owing to the previous dry period, until after the 26th, on which date heavy to excessive rains set in over the watersheds of the Lower Missouri, Des Moines, and Illinois Rivers. On May 31 freshet stages were reached along the Mississippi River from Quincy, Ill., to Cape Girardeau, Mo., while at Hannibal, Mo., a stage of 13.5 feet—0.5 feet above flood stage—was reached at 8 a. m. on the 31st.

The first advisory or flood-warning messages were disseminated by the St. Louis Weather Bureau office on May 26. By the 31st all the streams in the St. Louis River district, except the Gasconade, were either in flood or were rapidly approaching flood stage.

Since this flood period extends into the following month, a further discussion will appear in the next issue.

Missouri River.—Flood stages above Kansas City were not reached, although freshet stages prevailed in practically all tributaries in Kansas, Iowa, and Nebraska. Below Kansas City, however, flood stages obtained generally from the 28th, with a continuous rise to the end of the month. As a result of these bank-full stages in the lower reaches of the river, lowlands were inundated; but, owing to the higher elevation of most of the land under cultivation, no material damage to crops was sustained except at a few places. Railroad traffic was tied up in Kansas City and elsewhere, generally over the flooded sections, although the damage to tracks and bridges was local, and the greatest damage suffered by the shipping interests was the delay occasioned to traffic and transportation.

At Pattonsburg, Mo., Grand River overflowed its banks submerging the entire town. Families in one-story buildings and all merchandise were moved to upper stories for safety. Train service was completely cut off for some time.

At Lexington, Mo., the damage caused to crops in that vicinity and in Ray County amounted to thousands of dollars. Loss to bridges amounted approximately to $150,000.

At Bagnell, Mo., great damage was caused by the overflowing of the Osage River.

The following table gives the stages at and above flood stage at points along the Missouri River from Kansas City to the mouth, up to the end of the month:

Station.	River.	Flood stage.	First reached flood.		Highest stage.	
			Stage.	Date.	Stage.	Date.
		Feet.	*Feet.*		*Feet.*	
Kansas City, Mo	Missouri	22.0	22.3	May 28	25.2	May 30
Waverly, Mo	do	22.0	22.2	May 28	23.1	May 31
Chillicothe, Mo	Grand	18.0	19.7	May 27	30.1	May 30
Boonville, Mo	Missouri	21.0	22.0	May 29	24.0	May 31
Osceola, Mo	Osage	20.0	20.3	May 28	21.5	May 31
Hermann, Mo	Missouri	21.0	22.2	May 29	24.8	May 31

Since the crest of the flood in the lower Missouri was not reached at the end of the month, a further report thereon will be made in the next issue.

Arkansas River and tributaries.—In the Fort Smith River district the most destructive flood since 1908 began on May 25, and continued until June 3. This flood was due to frequent showers over Oklahoma and eastern Kansas from the 19th to the 23d, which thoroughly saturated the soil over the watersheds of the Arkansas, Verdigris, and Neosho Rivers, producing a steady though not rapid rise to stages considerably above normal in all of the larger tributaries. Heavy rains for four successive days then followed.

The Neosho River passed flood stage at Fort Gibson, Okla., during the night on May 24; the Verdigris, at North Muskogee, Okla., on the 27th; and the Arkansas River, at Fort Smith, on the 26th; and at Tulsa, Okla., on the 27th. The Arkansas remained above flood stage at Fort Smith from May 26 to June 2, inclusive. Although the flood stage was not reached at Wyandotte, Okla., the Neosho River overflowed its banks above and below that station. A flood warning for the Neosho River, and the Arkansas from the mouth of the Neosho to Fort Smith was issued on the 24th, and another for the Arkansas above the mouth of the Neosho on the 25th. The warnings were timely and well disseminated and nearly all property that could be protected was saved. The great bulk of the losses sustained were to unprotected farm lands, and even a considerable acreage of lands of this nature was saved by the construction of temporary levees after the receipt of the flood warnings.

The losses in the Fort Smith River district alone, as indicated by the receipt of a considerable number of reports, were as follows:

Tangible property, including buildings, municipal plants, highways and bridges	$50,000
Loss of crops	200,000
Loss of prospective crops (20,000 acres involved)	250,000
Loss of live stock and other movable property	10,000
Railroad bridges and roadbeds	50,000
Total loss	560,000
Money value of property saved by Weather Bureau warnings	75,000

In the lower Arkansas and White Rivers flood stages prevailed from the 28th or 29th, extending into the month of June.

The most disastrous effects of the flood in the upper river districts were probably in the watershed of the Neosho River, in the vicinities of Iola, and Horseshoe Bend, Kans., and were due in large measure to the breaking of levees in the vicinity of Horseshoe Bend on the morning of May 22. As a result, hundreds of acres of growing crops were flooded, and many fields of grain and vegetables were completely destroyed. Water stood on low farms from 5 to 15 feet deep. The estimated losses in Horseshoe Bend alone were placed at $3,800, while the total damages in the vicinities of Horseshoe Bend and Iola amounted, in the aggregate, to more than $10,000. Owing to the timely warnings issued by the Weather Bureau, however, farmers were on the lookout and in readiness for the flood, and not a single accident or loss of stock was reported.

Overflowing of the Arkansas at Great Bend and Nickerson, Kans., and of the small tributaries in the vicinity of Wichita, caused some slight damages to crops in the low lands, and to bridges.

The following table gives some of the highest stages in the Arkansas and its tributaries during the month:

Some of the highest stages in the Arkansas, May, 1915.

Station.	River.	Flood stage.	Crest stage.	Date of crest.
		Feet.	*Feet.*	
Dodge City, Kans	Arkansas	5.0		
North Muskogee, Okla	Verdigris	21.3	21.7	May 27
Emporia, Kans	Cottonwood	19.5	19.5	May 20
Neosho Rapids, Kans	Neosho	22.0	22.1	May 21
Le Roy, Kans	do	24.0	24.0	May 20
Iola, Kans	do	10.0	11.3	May 21
Oswego, Kans	do	20.0	20.1	May 27
Fort Gibson, Okla	Grand	22.0	24.3	May 25
Canton, Okla	North Canadian	3.0	4.6	May 25
Fort Smith, Ark	Arkansas	22.0	23.0	May 26
Dardanelle, Ark	do	20.0	20.3	May 26
Little Rock, Ark	do	23.0	23.2	May 28
Pine Bluff, Ark	do	25.0	25.0	May 29
Calico Rock, Ark	White	18.0	21.0	May 28
Batesville, Ark	do	18.0	21.0	May 29
Georgetown, Ark	do	22.0		

Red River and tributaries.—On April 23 heavy rains set in over portions of the upper watershed of the Red River and continued through the 26th, extending generally over the entire watershed. The resulting flood was the worst over this district since 1908. Aside from the damages due to the interruption of train service and traffic, conservative estimates place the actual losses occasioned by the flood at not less than one and one-half million dollars. Considerable losses extended from Oklahoma City to below Shreveport, La., but the heaviest losses were sustained in Lafayette, Miller, Hempstead, and Little River Counties, Ark., and in Bowie County, Texas.

The flood period extended over the latter part of April and the first days of May. The highest stages in feet and the dates of occurrence were as follows:

Station.	River.	Flood stage.	Crest stage.	Date of crest.
		Feet.	*Feet.*	
Denison, Tex	Red	22.0	19.0	Apr. 28.
Arthur City, Tex	do	27.0	30.5	Apr. 29.
Fulton, Ark	do	28.0	34.1	May 2.
Springbank, Ark	do	29.0	33.5	May 6-7.
Shreveport, La	do	29.0	29.1	May 9.
Alexandria, La	do	36.0	36.1	May 17-18.
Whitecliffs, Ark	Little	28.0	28.2	Apr. 29.
Ringo Crossing, Tex	Sulphur	20.0	21.0	Apr. 25-27.
Finley, Tex	do	24.0	31.4	Apr. 28.
Jefferson, Tex	Cypress	18.0	23.6	Apr. 28-29.

Statistics of money losses resulting from the flood have been carefully compiled from over 100 written reports and are as follows:

Loss of tangible property, mostly to highways, bridges, fences, levees, pipe lines, houses, and land lost by caving banks	$255,000
Corn and cotton for seed	25,000
Prospective crops (150,000 acres involved)	1,000,000
Live stock, implements, etc	70,000
Loss due to suspension of business	190,000
Total loss	1,540,000
Money value of property saved by Weather Bureau warnings, largely live stock	750,000

The timely warnings issued by the Weather Bureau at the earliest possible moment were based almost entirely upon scattered heavy rains and prepared people in advance of the flood to move their property and stock to places of safety.

Rivers of Mississippi.—Excessive general rains on May 7 and 8 caused sudden and sharp rises in the Chickasawhay River at Shubuta and Enterprise, Miss., in the Pascagoula River at Merrill, Miss., and in the Pearl River at Edinburg and Jackson, Miss. Flood stages were reached at Edinburg on May 7 and continued through the 18th, with a crest of 20 feet on the 15th. At Jackson a crest stage of 19.8 feet prevailed on the 15th and 16th. The stages were due to additional heavy rains on the 11th and 12th. None of the other streams reached flood stage. No damage was sustained in the basins of the Chickasawhay and Pascagoula Rivers, but at Jackson, on the Pearl, nominal damages and much inconvenience resulted from an overflow of Town Creek on May 7.

The advices of sudden rises furnished by the Weather Bureau were useful to the lumbering interests as well as to the agricultural interests.

Rivers of Alabama.—A flood of comparatively small extent in the Tombigbee River below Demopolis, Ala., inundating only the lowest river bottoms, occurred during May. The river at Demopolis was above flood stage from the 12th to the 18th, inclusive, with a crest of 40.8 feet on the 14th. A stage of 42.4 feet (0.6 foot below flood stage) was reached at Tuscaloosa, Ala., on the Black Warrior River on May 8. Timely warnings were issued by the Weather Bureau.

Statistics relative to the flood on the Tombigbee River, based upon data collected from reports by the public, are as follows:

Loss of prospective crops (1,430 acres involved)	$1,200
Loss due to suspension of business	20
No other losses reported.	
Money value of property saved by the issuance of flood warnings by the Weather Bureau	48,000

This relatively great protection to property is explained by the fact that over 1,200 head of live stock were moved from lowlands in advance of the flood.

Rivers of South Carolina.—Freshet stages occurred in the Black and the Santee Rivers of South Carolina, due to heavy local rains in scattered sections of the respective watersheds, but no material damages were reported. The Black River was above flood stage at Kingstree, S. C., from the 15th to the 17th, inclusive, with a crest stage of 12.7 feet on the 16th. The Santee River was above flood stage at Ferguson, S. C., from the 12th to the 19th, inclusive, with a crest stage of 12.8 feet on the 15th, 16th, and 17th, and at Rimini, S. C., from the 10th to the 16th, inclusive, with a crest stage of 12.9 feet on the 15th.

Rivers of California.—Freshet stages occurred in the rivers of California, with flood stages as follows: At Sacra-

mento, Cal., on the Sacramento River; at Carters ranch, Cal., on the Kaweah River; at Piedra, Cal., on the Kings River.

In the California Valley the generally heavy rainfalls were beneficial to crops of grain, while the only damage of consequence was suffered by the Southern Pacific Company by the suspension of traffic and the washing away of tracks and bridges. An estimate of the probable damages sustained, however, is not as yet available.

Rivers of Texas.—Flood stages occurred in the rivers of Texas during the early part of May as follows: Sabine River, at Logansport, La.; Trinity River, Long Lake, Tex.; Liberty, Tex.; Fort Worth, Tex.; Dallas, Tex.; Brazos River, at Washington, Tex.; Rosenberg, Tex.; Hempstead, Tex.; Nueces River, at Cotulla, Tex.; Neches River, at Rockland, Tex.; Guadalupe River, at Victoria, Tex. A report of the floods of Texas during the latter part of April and the first part of May will be found in the April, 1915, REVIEW.

Freshet stages occurred in the rivers of Iowa, Illinois, and Indiana, attended with some slight damages to crops in the lowlands due to the overflowing of small streams. In the vicinity of Springfield, Ill., considerable damage and inconvenience was caused by the overflowing of the Sangamon River, due to unusually excessive rainfall.

The Penobscot River, at West Enfield, Me., reached flood stage on May 2 and 3, with a crest of 12.6 feet on the 2d.

Recapitulation of flood loss.—The greatest damages caused by the floods of May seem to have been sustained in the watersheds of the Arkansas and Red Rivers. The estimated damages in these two river valleys alone exceeds $2,000,000, while the losses elsewhere over the country, though somewhat more local in extent, will increase the foregoing figures. Since the crest in the Lower Missouri did not occur until the following month, the losses, if any, are not included in the above.

These heavy losses were, in the main, unpreventable, and were sustained largely by the farming, shipping, and transportation interests. The money value of property, mainly live stock, saved by the timely warnings of the Weather Bureau in these two river valleys alone, is conservatively estimated at $825,000, while in the Tombigbee Valley the saving of live stock is estimated at $48,000.

Hydrographs for typical points on several principal rivers are shown on Chart I. The stations selected for charting are Keokuk, St. Louis, Memphis, Vicksburg, and New Orleans, on the Mississippi; Cincinnati and Cairo, on the Ohio; Nashville, on the Cumberland; Johnsonville, on the Tennessee; Kansas City, on the Missouri; Little Rock, on the Arkansas; and Shreveport, on the Red.

MEAN LAKE LEVELS DURING MAY, 1915.

By UNITED STATES LAKE SURVEY.

[Dated: Detroit, Mich., June 5, 1915.]

The following data are reported in the "Notice to Mariners" of the above date:

Data.	Lakes.			
	Superior.	Michigan and Huron.	Erie.	Ontario.
Mean level during May, 1915:	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Above mean sea level at New York	601.65	579.64	571.69	245.15
Above or below—				
Mean stage of April, 1915	+0.31	+0.16	+0.24	+0.11
Mean stage of May, 1914	−0.58	−0.68	−1.21	−1.80
Average stage for May, last 10 years	−0.30	−1.07	−1.12	−1.76
Highest recorded May stage	−1.40	−3.88	−2.73	−3.80
Lowest recorded May stage	+0.83	+0.08	+0.38	+0.19
Probable change during June, 1915	+0.3	+0.3	+0.2	+0.1

SECTION V.—SEISMOLOGY.

SEISMOLOGICAL REPORTS FOR MAY, 1915.

W. J. HUMPHREYS, Professor in Charge of Seismological Investigations.

[Dated: Washington, D. C., June 29, 1915.]

TABLE I.—*Noninstrumental earthquake reports, May, 1915.*

Day.	Approximate time, Greenwich Civil.	Station.	Approximate latitude.	Approximate longitude.	Intensity Rossi-Forel.	Number of shocks.	Duration.	Sounds.	Remarks.	Observer.
		CALIFORNIA.								
	H. m.		° ′	° ′			M. s.			
1	21 48	Brawley	32 50	115 40	2	1		Faint	Period of unrest continued from April.	M. D. Witter.
3	7 30	Branscomb	39 40	123 40	3	1				A. J. Haun.
3	19 52	Susanville	40 27	120 40	3	2		Rattling	Windows rattled	Geo. H. Taylor.
6	12 10	Branscomb	39 40	123 40	5	1	0 5			A. J. Haun.
	12 10	Eureka	40 48	124 11	2	2	5			U. S. Weather Bureau.
	12 10	Fort Bragg	39 23	123 48	5	1	15			W. F. Fuller.
	12 10	Shively	40 25	123 56	3	2	4			Frank Essig.
11	11 45	Cahuilla	33 32	116 43	4	1		Rumbling		Dr. Wm. L. Shawk.
	11 45	Campo	32 38	116 28	4	1		Rattling		Seth Swenson.
	11 45	Julian	33 05	116 37	5	1	8	Rumbling	Very light shock, 11h	J. H. L. Vogt.
	11 45	Nellie	33 22	116 52	3	1	5	do		W. H. Hargrave.
13	12 00	Aguanga	33 26	116 51	3	1	10	Faint		Mrs. N. C. Matzen.
28	18 30	Glennville	35 40	118 45	2	1			Shook houses	C. H. Likely.
28	18 55	Bakersfield	35 22	119 01	5	2	3		Rocking motion	P. W. Doane.
29	6 45	Fresno	36 43	119 49	2	1			Felt from Merced to Bakersfield	U. S. Weather Bureau.
	6 45	Hot Springs	35 56	118 34	3	3	4			T. E. Evans.
	6 45	Lone Pine	36 37	118 01	5	2	8	Rumbling		G. F. Marsh.
		WYOMING.								
		Yellowstone Park:								
8	16 10	Canyon Station	44 58	110 42	5	3	15		Shook buildings	J. A. Schady.
	16 10	Lake Station	44 56	110 40	5	2	10		Furniture moved	E. E. Brown.
	16 10	Tower Falls	44 50	110 36	5		20			B. Ashcroft.

TABLE 2.—*Instrumental reports, May, 1915.*

Time used: Mean Greenwich, midnight to midnight. Nomenclature: International.

[For significance of symbols see this REVIEW, December, 1914, p. 689.]

Alaska, **Sitka**, **Magnetic Observatory**, U. S. Coast and Geodetic Survey. J. W. Green.

Lat., 57° 03′ 00″ N.; long., 135° 30′ 06″ W. Elevation, 15.2 meters.

Instruments: Two Bosch-Omori, 10 and 12 kilograms.

Instrumental constants: E: V 10, T_0 17.4; N: V 10, T_0 15.6

Date.	Character.	Phase.	Time.	Period. T	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915.			H. m. s.	Sec.	μ	μ	Km.	
May 1		Pe	5 07 54	2				
		S	5 14 08	13				
		L_E	5 19 46	26				
		L_N	5 22 00	23				
		M_E	5 23 04	20	710			
		M_N	5 18 00			650		
		M_N	5 27 26	11		280		
		C_E	5 32 00	18				
		F_E	7 26 00					
6		L_E	12 16 35	16				Preliminary phases uncertain.
		L_N	12 15 20	16				
		M	12 17 23	16	90			
		M_N	12 18 50	12		20		
		C_E	12 22 00	10				
		C_N	12 26 00	13				
		F	12 40 00					

Arizona. **Tucson**. **Magnetic Observatory**, U. S. Coast and Geodetic Survey. F. P. Ulrich.

Lat., 32° 14′ 48″ N.; long., 110° 50′ 06″ W. Elevation, 769.6 meters.

Instruments: Two Bosch-Omori, 10 and 12 kg.

Instrumental constants: E: V 10, T_0 16; N: V 10, T_0 19.6

Date.	Character.	Phase.	Time.	Period. T	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915.			H. m. s.	Sec.	μ	μ	Km.	
May 1		P	5 11 19	4				
		S	5 20 26	7				
		L	5 29 16	28				
		M_E	5 35 23	22	100			
		M_N	5 36 40	20		40		
		C_E	5 44 00	18				
		F_E	7 36 00	14				
6		P	12 12 42	4				
		eI_E	12 18 41	11				
		eL_N	12 17 42	14				
		M_E	12 19 38	11	100			
		M_N	12 18 54	11		110		
		C_E	12 27 00	8				
		F_E	13 08 00	6				
27		eE	14 22 06	4				Paper being changed on N.
		M_E	14 23 10	4	10			
		C_E	14 25 00					

Arizona. **Tuson. Magnetic Observatory**—Continued.

Date.	Character.	Phase.	Time.	Period. T	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
May 27		e	14 39 20					
		M_E	14 40 24	5	10			
		M_N	14 40 14	4		10		
		C_E	14 46 28	4				
		C_N	14 42 28	4				
27		e	16 38 57	4				
		M_E	16 40 05	5	10			
		M_N	16 39 30	5		10		
		C	16 42 00					
27		e	19 27 03	4				
		M_E	19 28 16	4	10			
		M_N	19 27 40	4		10		
		C	19 30 00					
27		e	19 32 06	4				
		M_E	19 33 01	5	50			
		M_N	19 32 48	5		40		
		C	19 34 00					
27		e	19 49 55	4				
		M	19 51 09	5	30	30		
		C	19 54 00	4				
29		e	6 49 44	4				
		M	6 50 20	5	90	70		
		C	6 53 00	4				
29		e	8 33 34	3				
		M	8 34 10	4	20	20		
		C	8 36 00					

California. **Point Loma. Raja Yoga Academy.** F. J. Dick.

Lat., 32° 43′ 03″ N.; long., 117° 15′ 10″ W. Elevation, 91.4 meters.

Instrument: Two-component, C. D. West seismoscope.

Date.	Character.	Phase.	Time.	Period. T	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
May 1			8 30 00		500	100		

Colorado. **Denver. Sacred Heart College. Earthquake Station.** A. W. Forstall, S. J.

Lat., 39° 40′ 36″ N.; long., 104° 56′ 54″ W. Elevation, 1,655 meters.

Instrument: Wiechert 80 kg., astatic, horizontal pendulum.

Date.	Character.	Phase.	Time.	Period. T	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
May 1		L_N	5 31 00	40		7		Good record, but preliminary phases not discernible. Said to have been in Japan, but not confirmed.
		L_E	5 31 00	35	6			
		M_E	5 33 00	35	8			
		M_N	5 34 00	40		9		
		C_E	5 39 00	20?				
		C_N	5 40 00	20?				
		F_E	5 55 00					
		F_N	6 08 00					
4								Activity on E-W from 21^h 54^m to 22^h.
8								Long slender waves on both components from 18^h 20^m to 19^h; especially on E-W.
12								Activity on E-W from 20^h 25^m to 20^h 26^m.
13								Activity on E-W from 20^h to 20^h 10^m.
14								Activity on E-W. Visible all day.
22								Broken, irregular waves on E-W from 21^h 28^m to 21^h 34^m.
30								Irregular waves on E-W from 16^h to 20^h 03^m.

District of Columbia. **Washington. U. S. Weather Bureau.**

Lat., 38° 54′ N.; long., 77° 03″ W. Elevation, 21 meters.

Instrument: Marvin (vertical pendulum), undamped. Mechanical registration.

Instrumental constants........ V 110, T_0 6

Date.	Character.	Phase.	Time.	Period. T	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
May 1	II_u	iP	5 12 24	3			8,935	
		S	5 22 31	6				
		$SR1_N$	5 24 40					
		$SR2_E$	5 27 56	8				
		$SR3_E$	5 31 38					
		eL	5 36 22	16				
		M_E	5 45 16	20	14			
		M_N	5 45 16	20		14		
		M_E	5 57 30	20	27			Distinct long waves continue for over 3 hours.
		F	10 00 00					
3	I_u	P_N	3 26 40	4			9,190	
		S_N	3 37 00					
		eL_E	3 51 50					
		M_E	4 05 30	18				
		L_N	4 14 00	18				
		F	4 30 00					
3	I_u	P_N	4 24 22				8,875?	Origin presumably the same as that of preceding.
		S_N?	4 34 26					
		L_N	5 14 00	22				
		L_E	5 14 00	22				
		F	5 50 00					
6	I_r	P_N	12 15 43				4,015	
		S_N	12 21 31					
		eL_N	12 25 05					
		M_N	12 30 00	20		14		
		F	13 20 00					
12	I_u	P_N	10 39 58				7,215	All amplitudes very small.
		S_N	10 48 38					
		L_E	11 03 00	24				
		F	11 40 00					
17	I_r	P_N	13 15 10				3,125	All amplitudes very small.
		S_N	13 20 02					
		L_N	13 25 08					
		L_N	13 28 00	16				
		F	13 40 00					
27	I_r	P_N	19 42 03				3,125	Long waves not perceptible. Another quake from 20^h 05^m to 20^h 10^m, phases indistinct.
		S_N	19 46 55					
29	I_r	P_N	7 02 55				1,600?	No long waves perceptible.
		S_E?	7 05 41					
		F	7 10 00					
29		e	8 46 57					
		F	8 50 00					
30		P_N	13 32 00				990?	
		S_N	13 33 57					
		L_N	13 34 52					
		F	13 40 00					

District of Columbia. **Washington. Georgetown University.** F. L. Tondorf, S. J.

Lat., 38° 54′ 25″ N.; long., 77° 04′ 24″ W. Elevation, 42.4 meters. Subsoil: Decayed diorite.

Instruments: Wiechert 200 kg., astatic horizontal pendulums.

Instrumental constants:	V	T_0	ε
E	165	5.4	0
N	143	5.2	0

Date.	Character.	Phase.	Time.	Period. T	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
May 1	I_r	iP_N	5 12 24					P_E less distinct than P_N. S_E much more discernible.
		iP_E	5 12 34					
		S_N	5 22 30					
		S_E	5 22 40					
		M_N	5 44 42	12–18		6		
		M_E	5 45 0?	20	11			
		F_N	7 02 32?					
		F_E	?					
5	II_r	eP_N	12 25 42					
		P_E	?					
		S_E	12 29 24					
		S_N	12 29 50					
		L_N?	12 31 43	10		5		
		L_E	12 32 24	10				
		L_N	12 32 47			4		
		F_N	12 39 50					
		F_E	12 45 40					

Hawaii. **Honolulu. Magnetic Observatory.** U. S. Coast and Geodetic Survey. Wm. W. Merrymon.

Lat., 21° 19′ 12″ N.; long., 158° 03′ 48″ W. Elevation, 15.2 meters.

Instrument: Milne seismograph of the Seismological Committee of the British Association.

Instrumental constant.. T_0 19.2.

Date.	Character.	Phase.	Time.	Period. T	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
May 1		P	5 09 00					
		S	5 15 54					
		L	5 21 30	25				
		M	5 25 00		17,000*			
		C	7 04 36					
		F	11 05 54					
2		P	4 14 24					
		S	4 18 18					
		L	4 22 18	24				
		M	4 25 54		1,200*			
		C	4 33 24					
		F	5 07 54					
3		P	3 29 36					
		S	3 33 24					
		L	3 37 18	21				
		M	3 40 12		2,100*			
		C	3 47 54					End covered by beginning of next earthquake.
3		P	4 22 48					
		L	4 35 06	27				
		M	4 40 24		2,800*			
		C	4 53 42					
		F	7 16 36					
3		e	12 31 42					
		M	12 51 18		200*			
		P	13 10 24					
3		P	22 09 18					
		L	22 22 00	23				
		M	22 26 36		300*			
		C	22 31 18					
		F	22 55 36					
5		P	11 30 18					
		L	11 42 18					
		M	11 49 42	20	1,000*			
		C	11 59 36					
		F	12 48 24					
5		eL	15 53 24					
		M	15 54 24	20	200*			
		F	16 15 48					
6		eP	12 17 00					
		eL	12 23 00					
		M	12 25 36	19	1,400*			
		C	12 40 00					
		F	13 39 00					
8		eL	15 09 18	22				
		M	15 15 18	19	200*			
		C	15 41 54					
		F	16 08 12					
12		eP	11 41 36					
		eL	12 09 00	20				
		M	12 33 48		200*			
		C	12 44 24					
		F	13 05 00					
14		P	6 56 42					
		S	7 00 12					
		L	7 04 00	24				
		M	7 06 48	18	800*			
		C	7 13 42					
		F	7 56 24					
14		eL	14 47 00	20				
		M	14 54 36		200*			
		F	15 10 06					
16		eL	17 09 00	18				
		M	17 10 48		200*			
		F	17 18 00					
16		eL	17 50 00	20				
		M	17 52 18		200*			
		F	18 03 00					
21		eL	5 48 30	22				
		M	5 53 12		200*			
		F	6 11 42					
21		P	12 32 54					
		eL	12 59 00	20				
		M	13 01 30		200*			
		F	13 09 12					

* Trace amplitude.

Kansas. **Lawrence. University of Kansas.** Department of Physic and Astronomy. F. E. Kester.

Lat., 38° 57′ 30″ N.; long., 95° 14′ 58″ W. Elevation, 304.8 meters.

Instrument: Wiechert.

		V	T_0	ε
Instrumental constants..	E	121	3.7	3.7
	N	126	3.7	4.5

Date.	Character.	Phase.	Time.	Period. T	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
May 1		P	5 11 30	2				
		S	5 20 53	10				
		L	5 36 30	20	28	24		
6		P	12 14 21	3				Not certain as to seconds.
		S	12 18 45	6				
		L	12 22 26	16	7	28		
		F	12 56 00					

Maryland. **Cheltenham. Magnetic Observatory.** U. S. Coast and Geodetic Survey. George Hartnell.

Lat., 38° 44′ 00″ N.; long., 76° 50′ 30″ W. Elevation, 71.6 meters.

Instruments: Two Bosch-Omori, 10 and 12 kg.

		V	T_0
Instrumental constants..	E	10	31
	N	10	29

Date.	Character.	Phase.	Time.	Period. T	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
May 1		P_E	5 12 23	3				
		P_N	5 12 29	3				
		S_E	5 22 27	8				
		S_N	5 22 42	12				
		L_E	5 38 31	20				
		L_N	5 39 21	16				Phases on E more clearly defined than on N.
		M_E	5 48 50	26	100			
		M_N	5 45 40	26		150		
		C_E	5 58 ..	16				
		C_N	6 06 ..	18				
		F	7 04 ..	12				
6		eP_N	12 21 55					Phases on E uncertain.
		L	12 29 12	14				
		M	12 30 12	17	10	50		
		C	12 37 ..	10				
		F	12 41 ..					

Massachusetts. **Cambridge. Harvard University Seismographic Station.** J. B. Woodworth.

Lat., 42° 22′ 36″ N.; long., 71° 06′ 59″ W. **Elevation, 5.4 meters. Foundation: Glacial sand over clay.**

Instruments: Two Bosch-Omori 100 kg. horizontal pendulums, undamped (mechanical registration).

		V	T_0
Instrumental constants..	E	80	23
	N	50	25

Date.	Character.	Phase.	Time.	Period. T	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
May 1		*0*	4 59 00				8,980	Kurile Islands?
		eP_N	5 12 16					
		eP_E	5 12 21					
		S_E	5 22 25	32				
		SR1?	5 28 14					
		SR2	5 28 39					
		eL_E	5 37 29					
		M_N	5 46 15			114		
		M_N	5 50 07			134		
		M_N	5 53 41					
		C_N	5 57 29					
		F	8 17 00					
1		e?	9 29 17				3,850?	S? Possibly part of last.
		L_E	9 32 31	20				No trace on N.
		L_E	9 34 06	16				
		L_E	9 36 40	15				
		F	9 38 00					
5		*0*?	11 17 00				8,730?	*0* from eL-S. P in microseisms.
		S?	11 39 31	8				
		eL	11 53 50	18				
		L_E	12 19 07					
		L_N	12 19 31					
		L_E	12 20 49	20				
		L_E	12 33 31	20-15				
		F?	12 50 00					
6		*0*	12 08 02				4,820	
		eP_E	12 16 26					
		?	12 19 55	6				
		S	12 22 58					
		eL	12 33 44					
		M	12 33 59					
		M	12 35 14					
		F	13 20 00					

0 = Time at origin.

Massachusetts. **Cambridge. Harvard University Seismographic Station**—Continued.

Date.	Character.	Phase.	Time.	Period. T	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
May 8		e	14 44 42					Disturbance of uncertain origin.
		to	15 10 00					
12		*0*	10 29 42				6,075	*0* from eL–P. S not well defined.
		eP_E	10 39 29					
		eE	10 42 14					
		eN	10 43 02	8				
		eL_E	10 55 23					
		L_E	10 57 04					
		L_E	10 59 26	24				
		L_E	11 10 17	15				
		F	11 30 00					
21		*0?*	4 27 46				8,800?	S uncertain.
		eP_N	4 40 00					
		eL	5 04 36					
		L_E	5 08 09	16				
		L_E	5 10 30	24				
		L_E	5 14 00	16				
		F	5 30 20					

O=Time at origin.

Missouri. **Saint Louis. St. Louis University.** Geophysical Observatory. J. B. Goesse, S. J.

Lat., 38° 38′ 15″ N.; long., 90° 13′ 58″ W. Elevation, 160.4 meters. Foundation: 12 feet of tough clay over limestone of Mississippi system, about 300 feet thick.

Instrument: Wiechert 80 kg. astatic, horizontal pendulum.

Instrumental constants.. V 80, T_0 7, ϵ:1 5:1

Date.	Character.	Phase.	Time.	Period. T	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
May 1	II_r	eP	5 11 55				8,300	
		eS	5 21 33					
		L	5 35 00					
		M_E	5 42 12	24	50			
		M_N	5 43 09	21		38		
		M_E	5 44 18	19	38			
		M_N	5 46 15	18		50		
		F	7 00 00					
6	I_r	eP	12 15 01				3,300	
		eS?	12 20 03					
		L_N	12 23 00					
		L_E	12 24 00					
		M_E	12 25 15	11	12			
		M_N	12 25 24	12		62		
		F	12 50 00					

New York. **Buffalo. Canisius College.** John A. Curtin, S. J.

Lat., 42° 53′ 02″ N.; long., 78° 52′ 40″ W. Elevation, 190.5 meters.

Instrument: Wiechert 80 kg. horizontal.

Instrumental constants: ————.

[Report for May, 1915, not received.]

New York. **Fordham. Fordham University.** W. C. Repetti, S. J.

Lat., 40° 57′ 47″ N.; long., 73° 53′ 08″ W. Elevation, 23.9 meters.

Instrument: Wiechert 80 kg.

Instrumental constants.. T_0 {E..6.6, N..7.1

Date.	Character.	Phase.	Time.	Period. T	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
May 1	II_u	iP_N	5 07 54					Trace of E-W component from 5h 08m 15s till 5h 33m 00s lost through defective smoking of record.
		P_N	5 08 02	8.4		6		
		P_N	5 08 17	10.2		7		
		iP_E	5 07 54					
		P_E	5 07 59	3.0	2			
		$PR1_N$	5 10 49	11.4		5		
		$PR2_N$	5 12 39	10.2		4		
		iS_N	5 17 41					
		S_N	5 18 12	7.2		15		
		S_N	5 18 52	16.0		66		
		$SR1_N$	5 23 35					
		$SR2_N$	5 26 46					
		$SR2_N$	5 27 36	20.0		35		
		L_N	5 32 24	11-22				
		$M1_N$	5 41 05	21.0		170		

New York. **Fordham. Fordham University**—Continued.

Date.	Character.	Phase.	Time.	Period. T	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
May 1		$M2_N$	5 45 37	19.0		180		
		M_E	5 50 23	22.0	350			
		C_E	5 57 00					
		C_N	6 00 00					
		F_N	7 55 00					
		F_E	7 55 00					
3	I	eL_N	5 07 34					
		F_N	5 23 34					
	I	eL_N	6 06 30					
		M_N	6 10 51	23.0		13		
		L_E	6 09 30					
		F_N	6 17 00					
5	I	L_N	12 17 04	18.0				
		F_N	12 25 34					
6	I	eP_N?	12 09 06					
		eP_E?	12 09 13					
		S_E?	12 14 44					
		S_N?	12 14 59					
		L_N	12 20 40					
		L_E?	12 24 25					
		$M1_N$	12 25 54	19.0		20		
		$M1_E$	12 27 00	10.0	5			
		$M2_N$	12 27 22	11.0		19		
		$M2_E$	12 27 28	12.0	10			
		F_N	13 00 00					
17	I	P_N?	16 12 08	4.0				
		P_E?	16 12 11	3.0				
		S_N?	16 16 55	4.0				
		eL_N	16 21 35	20.0				

Panama Canal Zone. Balboa Heights. Isthmian Canal Commission.

Lat., 8° 57′ 39″ N.; long., 79° 33′ 29″ W. Elevation, ——.

Instruments: Two Bosch-Omori 25 kg.

Instrumental constants.. V 8, T_0 20

[No earthquake recorded during May, 1915.]

Vermont. **Northfield. U. S. Weather Bureau. Wm. A. Shaw.**

Lat., 44° 10′ N.; long., 72° 41′ W. Elevation, 256 meters.

Instruments: Two Bosch-Omori, mechanical registration.

Instrumental constants.. {E..V 10, T_0 15; N..V 10, T_0 16

Date.	Character.	Phase.	Time.	Period. T	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
May 1	II_u	iP_N	5 12 11				8,755	
		S_N	5 22 09					
		$SR2_E$	5 27 17					
		$SR2_E$	5 27 25					
		L_N	5 44 30	28				
		M_N	5 45 45			45		
		M_N	5 51 00			55		
		M_N	5 54 15	28		55		
		M_N	5 58 15			45		
		F	9 00 00					
3		P_N?	3 26 31					
		S_N	3 36 40					
		M_N	4 05 00	18				
		F?	4 20 00					Second earthquake beginning about 4h 24m, continued until 5h 30m.
5		P_N?	11 32 00					Record faint; phases doubtful.
		F	12 00 00					
6		P_N	12 15 16				5,165?	
		S_N?	12 22 07					
		L_N	12 25 20	16				
		F	13 20 00					
27		L_N	19 50 30					
29		P_N?	7 03 07				1,700?	No long waves visible.
		S_N?	7 05 12					
		F	7 12 00					

Canada. Ottawa. Dominion Astronomical Observatory. Earthquake Station. Otto Klotz.

Lat., 42° 23′ 38″ N.; long., 75° 42′ 57″ W. Elevation, 83 meters.

Instruments: Two Bosch photographic horizontal pendulums, one Spindler & Hoyer 80 kg. vertical seismograph.

Instrumental constants.. V 120, T_0 26

Date.	Character.	Phase.	Time.	Period. T	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
May 1	......	iP	5 11 56	3			8,420	The L waves continue for over 4 hours, hence must show some LRs. The average speed of the L waves is about 220 km./min.; but this velocity does not fit in very well; 270 km./min. fits best, hence, and for other reasons, the Ls are interpreted as the various LR's.
		S	5 21 37	6				
		eL	5 33 05	44				
		M_N	5 43 03	24		65		
		M_N	5 48 03	20		70		
		M_E	5 52 00	20	65			
		M_N	5 53 00	18		80		
		L	{5 56 00–	18				
			6 16 00	18				
		L	6 29 00	16				
		L	6 49 00	12				
		LR1	6 58 00	12–16				
		L	7 21 00	20				
		L	7 27 00	13				
		L	7 43 00	18				
		LR2	7 59 00	20				
		L	8 21 00	18				
		LR3	9 25 05	20				
		L	9 38 00	16				
		F	9 50 00					
2	......	P_N?	4 10 19	2			9,280?	
		PR1?	4 13 54					
		PR2?	4 16 10					
		S?	4 20 43	6				
		eL	4 37 09	20				
		L	4 39 00	20				
		L	{4 43 00–	18				
			4 50 00	18				
		L	{4 52 00–	16–14				
			5 02 00					
		F	5 15 00					
3	......	P	3 26 14				8,640	
		S	3 36 08					
		L	3 50 05	30				
		L	3 55 00	18				
		L	{4 04 00–	14				
			4 20 00	14				
		i_N	4 24 47	4				i_N apparently another quake, but no S shows.
		L	5 00 00	40				
		L	5 06 00	30				
		L	5 14 00	20				
		L	5 28 00	18				
		F	6 10 00					
5	......	P_N?	11 32 08				8,000?	
		eL	11 53 00	40				
		L_E	12 12 00	24				
		L_N	12 15 03	30				
		L	{12 18 00–	20–18				
			12 38 00					
		F	13 00 00					
6	......	P	12 16 15	4			3,960	
		S	12 22 00	10				
		L_E	12 27 05	30				
		L_N	12 27 06	40				
		M_N	12 29 07	14		50		
		M_E	12 32 00	14	45			
		L	12 34 00	8				
		L	12 42 00	8				
		F	13 30 00					
8	......	L_E	14 41 00	20				L_N masked by microseisms.
		L_E	14 57 00	16				
		F	15 10 00					
12	......	P_E?	10 40 13				6,500?	
		S_N?	10 49 07	6				
		L_N	10 57 00	28				
		L_E	11 04 06	20				
		L_N	11 05 06	20				
		L	{11 11 00–	18–14				
			11 36 00					
		F	12 00 00					
14	......	e	6 52 49					Phases difficult to read.
		L	7 21 00	18				
		L	7 25 00	17				
		L	7 31 00	14				
		L	7 47 00	14				
		F	8 00 00					
17	......	P_N	13 17 23	4			2,740?	
		S_N?	13 21 47	8				
		L_N	13 26 02	14				
		L_E	13 27 00	20				
		L	13 29 00	20				
		F	13 50 00					

Canada. Ottawa. Dominion Astronomical Observatory—Continued.

Date.	Character.	Phase.	Time.	Period. T	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
May 18	......	e_N	14 56 11				5,600?	
		S_E?	15 03 27	6				
		eL	15 10 03	20				
		L	15 13 00	16				
		F	15 20 00					
21	......	e_N?	4 43 20				7,000?	N somewhat masked by microseisms.
		e_E	4 43 24					
		e_N	4 44 12					
		eL_N	5 01 05	40				
		L_N	5 05 06	30				
		L	5 09 00	20				
		L	{5 13 00–	18–14				
			5 24 00					
		F	5 35 00					
29	......	eL	0 35 03	20				
		L	0 37 00	16				
		F	0 45 00					
29	......	e_N	7 03 00					
		e_E	7 03 05	6				
		L_E	7 06 00	10				
		F	7 15 00					
29	......	eL_N	8 47 08	20				
		L_E	8 50 00	10				
		F	8 53 00					
30	......	e	13 31 38	2–3				
		L?	13 32 00	7				
		F	13 40 00					

Canada. Toronto. Dominion Meteorological Service.

Lat., 43° 40′ 01″ N.; long., 79° 23′ 54″ W. Elevation, 113.7 meters. Subsoil: Sand and clay.

Instrument: Milne horizontal pendulum, North. In the meridian.

Instrumental constant.. T_0 18. Pillar deviation, 1 mm. swing of boom = 0.59″.

[Report for May, 1915, not received.]

Canada. Victoria, B. C. Dominion Meteorological Service.

Lat., 48° 24′ N.; long., 123° 19′ W. Elevation, 67.7 meters. Subsoil: Rock.

Instrument: Milne horizontal pendulum, North. In the meridian.

Instrumental constant.. T_0 18. Pillar deviation, 1 mm. swing of boom = 0.54″.

[Report for May, 1915, not received.]

TABLE 3.—*Late reports.* (*Instrumental.*)

Missouri, Saint Louis. St. Louis University, Geophysical Observatory.

J. B. Goesse, S. J.

Lat., 38° 38′ 15″ N.; long., 90° 13′ 58″ W. Elevation, 160.4 meters. Foundation, 12 feet of tough clay over limestone of Mississippi System, about 300 feet thick.

Instrument: Wiechert 80 kg. astatic, horizontal pendulum.

Instrumental constants.. V 80, T_0 7, ε:1 5:1

Date.	Character.	Phase.	Time.	Period.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
Apr. 23	I_r	eP	15 37 18				4,450	Record on N-S component too slight for analysis.
		iS	15 43 30					
		L_E	15 46 00					
		M_E	15 46 04	5	25			
		F	15 55 00					

SECTION VI.—BIBLIOGRAPHY.

RECENT ADDITIONS TO THE WEATHER BUREAU LIBRARY.

C. FITZHUGH TALMAN, Professor in charge of Library.

The following have been selected from among the titles of books recently received as representing those most likely to be useful to Weather Bureau officials in their meteorological work and studies.

Allahabad. Meteorologist.
Administration report, 1914-15. Allahabad. 1915. 4 p. 33 cm.
Brief sketch of the meteorology of the United Provinces, 1914. Allahabad. 1915. 5 p. 33 cm.
Monthly and annual rainfall table in the United Provinces of Agra and Oudh, 1914. [Allahabad. 1915.] 17 p. 33 cm.

Australia. Commonwealth bureau of meteorology.
Results of rainfall observations made in Queensland. Including all available annual rainfall totals from 1,040 stations for all years of record up to 1913; together with maps and diagrams. Melbourne. 1914. 285 p. maps. diagrs. 30½ cm.

Bates, C. G., Notestein, F. B., & Keplinger, Peter.
Climatic characteristics of forest types in the central Rocky Mountains. (*In* Proceedings of the Society of American foresters January, 1914, v. 9, no. 1, p. 78-94.)

Denmark. Meteorologiske Institut.
Nautisk-meteorologisk Aarbog. Nautical-meteorological annual. 1914. Kjøbenhavn. 1915. xlvi, 156 p. plates. 31 cm. [In Danish and English.]

Deuxième expédition antarctique française (1908-1910).
Description des côtes et banquises. Instructions nautiques. Par M. Bongrain. Paris. 1914. 59 p. plates. 28½ cm. [Climat—tempêtes, p. 4-6.]

Fleming, Robins.
Six monographs on wind stresses; wind pressure factors, specification requirements, mill-building stresses, rigid joint wind bracing for office buildings. Rev. and enl. reprints from Engineering news. New York. 1915. 76 p. 24 cm.

Galli, Ignazio.
Effetti dei fulmini globulari sull'uomo e sugli animali. Memoria quinta. Roma. 1914. 71 p. 29 cm. (Estratto dalle Memorie della Pont. accad. romana dei Nuovi Lincei, v. 32.)

Graarud, Aage.
Observations météorologiques faites au Spitsberg par l'Expédition Isachsen 1909-1910. Kristiania. 1913. 92 p. plate. 27½ cm. (Videnskapsselskapets Skrifter. I. Mat.-naturv. Klasse. 1913, No. 1.)

Grohmann, [Edmund].
Steht die Niederschlagsmenge noch im Einklange mit dem Wassergebrauch der Bevölkerung, Industrie und Landwirtschaft? Leipzig. [1914.] 15 p. 22 cm. (Schriften der Oekonomischen Gesellschaft im Königreich Sachsen.)

Iddings, Joseph P[axson].
The problem of volcanism. New Haven, *etc.* 1914. xvi, 273 p. plates. chart. 24 cm. (Silliman memorial lectures.)

Matthew, W. D.
Climate and evolution. New York. 1915. 171-318 p. 24½ cm. (Annals of the New York academy of sciences, v. 24.)

Mawson, *Sir* Douglas.
The home of the blizzard, being the story of the Australasian antarctic expedition, 1911-1914. London. [1915.] 2 v. plates. maps. 25½ cm.

Müller-Pouillet.
Lehrbuch der Physik und Meteorologie. 10. umgearb. u. verm. Aufl. 4. Band. 2. u. 3. Abteilung. Magnetismus und Elektrizität; von Walter Kaufmann, Alfred Coehn und Alfred Nippoldt. Braunschweig. 1914. xv, 623-1492 p. 3 pl. 25 cm.

Oregon. State immigration commission.
[Oregon almanac.] The State of Oregon; its resources and opportunities. 1915. Salem, Oregon. 1914. 320 p. 22 cm. ["Oregon's climate," p. 33-35. Climatic descriptions and statistics are also given under the heads of various counties and communities throughout the book.]

Pettersson, [Sven] O[tto].
Climatic variations in historic and prehistoric time. Göteborg. [1914.] 26 p. map. 45 cm. (Ur Svenska hydrografisk-biologiska kommissionens skrifter, häft 5.)
On the occurrence of lunar periods in solar activity and the climate of the earth. Göteborg. [1914.] 20 p. plate. 45 cm. (Ur Svenska hydrografisk-biologiska kommissionens skrifter, häft 5.)

Samoa-Observatorium.
13. Bericht, für das Jahr 1913-14, von E. Wiechert. 11-14 p. 24½ cm. (Aus den Nachrichten der K. Gesellschaft der Wissenschaften zu Göttingen. Geschäftliche Mitteilungen, 1914, 1. Heft.)

Schmidt, Albert.
Die Anomalien des jährlichen Temperaturganges und ihre Ursachen. 15 p. plate. 23 cm. (S.-A. aus den Jahrbüchern des Nassauischen Vereins für Naturkunde in Wiesbaden, 67. Jahrgang, 1914.)

Security trust & savings bank, Los Angeles.
Comparative rainfall chart of southern California. 1915 edition. Los Angeles. [1915.] 1 sheet folded to 21½ x 14 cm.

Straits Settlements. [Principal civil medical officer.]
Meteorological returns for the year 1914. Singapore. 1915. unp. 33½ cm.

Tarr, Ralph Stockman.
College physiography, published under the editorial direction of Lawrence Martin. New York. 1914. xxii, 837 p. plates. 22½ cm. [Pt. 3: The atmosphere.]

United States. Coast guard.
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RECENT PAPERS BEARING ON METEOROLOGY AND SEISMOLOGY.

C. FITZHUGH TALMAN, Professor in charge of Library.

The subjoined titles have been selected from the contents of the periodicals and serials recently received in the Library of the Weather Bureau. The titles selected are of papers and other communications bearing on meteorology and cognate branches of science. This is not a complete index of the meteorological contents of all the journals from which it has been compiled. It shows only the articles that appear to the compiler likely to be of particular interest in connection with the work of the Weather Bureau.

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NOTES FROM THE WEATHER BUREAU LIBRARY.

By C. FITZHUGH TALMAN, Professor in charge of Library.

WINDY-WEEP.

The Century Dictionary Supplement contains the word *windy-weep*, which is defined as "The cool, gentle, evening breeze which descends upon a broad, quiet river, with a sighing or weeping sound, from a forest in a tributary ravine." The term is said to be an American colloquialism, but it is not supported by a quotation, and the present writer has not been able to obtain any further information concerning it from the publishers of the dictionary in question. It does not appear to be in any other reference book. The writer will be grateful to any reader of the MONTHLY WEATHER REVIEW who will inform him as to the part or parts of the United States in which this term is used, or refer him to any instances of its use in literature.

NAMES OF THE COLD SPELL IN MAY.

The traditional cold spell in May has been known in this country as "blackberry," "dogwood," or "redbud winter." By J. R. Sage, long director of the Iowa Weather Service, it was named "the May dip." The same phenomenon is widely known in England as "blackthorn winter," and locally in Suffolk as "sloe-hatching time." The term "May chills" occurs in Sir W. N. Shaw's

"Forecasting Weather," page 138. German folklore has handed down the tradition of three successive cold days in May—viz, May 11–13 in northern Germany, and May 12–14 in southern Germany—dedicated in the church calendar to Sts. Mamertus, Pancratius, Servatius, and Bonifacius. These days, as well as the saints themselves, are known as the *gestrenge Herren* ("harsh masters") or *Eisheiligen* ("ice saints"). The *saints de glace* ("ice saints") are also well known in France.

A letter from Mr. J. F. Llewellyn, cooperative observer, Mexico, Mo., mentions "old woman's winter" as a name current in Germany for this period, the cold being "supposed to kill off old women." We are not familiar with this expression, though *Altweibersommer* is a common German designation for the European equivalent of our Indian summer.

Are there still other popular names for the cold spell in May?

HORSE LATITUDES.

The "horse latitudes" are the regions of calms and variable winds coinciding with the subtropical high-pressure belts lying on the poleward sides of the trade-winds; especially (and, according to a majority of writers, exclusively) the portion of the North Atlantic Ocean lying within the high-pressure belt; sometimes only the portion of this region near Bermuda. The principal attempts to explain this name are set forth in the following quotations:

The latitudes where these calms chiefly reign are named the horse-latitudes by mariners * * * because they are fatal to horses and other cattle which are transported to the last-mentioned continent [America].—G. Forster, "Voyage round the world," 1777, **2**, 581.

Vessels formerly engaged in conveying horses from New England to the West Indies were often detained in this calm belt for many days, when the large cargo of animals would exhaust the stock of water and become frantic with thirst. To save a portion, the rest were thrown overboard; hence the origin of the term "Horse Latitudes"—A. K. Johnston, "Physical atlas," 2d ed., 1856, p. 61, footnote 6.

Between these westerly winds and the northeast trade there is a part of the ocean where the winds are of a most changeable character * * * severe gales are common. * * * Speaking roughly, this part of the ocean lies between the Azores and Bermuda, and at a very early period in Atlantic navigation received from the Spaniards the name of *el golfo de las yeguas*, the mares' sea, in allusion to its boisterous nature and in contradistinction to *el golfo de las damas*, the ladies' sea, as the trade wind region was called, from its being so smooth and easy to sail over. It is this name, *el golfo de las yeguas*, which our sailors translated into The Horse Latitudes; and the story of ships laden with horses being becalmed so long that they had to throw their cargo overboard was probably invented at a comparatively recent date. * * * There are, however, many instances in English in which the word *horse* is used as a prefix denoting boisterous; as, for instance, a *horse-laugh*, *horse-play*.—J. K. Laughton, "Physical geography," 1870, p. 24–25.

Between the N. E. trades, and the westerly winds which prevail more or less to the northward of them, there is a belt of variable and light winds, which have, perhaps somewhat vaguely, been called the *Calms of Cancer*—a term which will not express its characteristics. It is called, also, the *Horse Latitudes*, from the fact that vessels in former years, employed in carrying horses to the West Indies, were frequently obliged to throw them overboard during the embarrassment caused by the continual changes, sudden gusts and calms, rains, thunder and lightning, which are general in it.—A. G. Findlay, "Memoir * * * of the northern Atlantic Ocean," 14th ed., 1879, p. 229.

Diesem friedlichen Gebiet [the trade-wind region between the Cape Verde Islands and the West Indies, called *el golfo de las damas*] stellten sie die stürmische See nördlich von 35° N. Br. gegenüber als *el golfo de las yeguas*, also das "Stutenmeer." Dieser sonderbare Name bezieht sich ursprünglich nicht auf den ganzen zwischen 35° und 40° quer über den Ozean laufenden Streifen, sondern nur auf den Meerestrich nordöstlich der Kanarien, wo nämlich die von Andalusien nach Westindien segelnden spanischen Truppen ihre Pferde in grosser Zahl auf ihren kleinen Schiffen verloren und über Bord warfen. Wie es scheint, ist unabhängig hiervon in der neueren Literatur ein diesem ähnlicher Ausdruck, nämlich die "Rossbreiten" (*horse latitudes*), in Aufnahme gekommen. Darunter wurde zunächst nur das Gebiet bei den Bermudas-Inseln zwischen 27° und 35° N. Br. verstanden, und Maury erklärt den Namen ebenfalls durch das gewohnheitsmässige Überbordwerfen von Pferden auf der Fahrt von den Neuengland-Staaten nach Westindien, woran hier die übermässige Verzögerung der Reise in den dort häufigen leichten Winden und Stillen schuld war; er selbst aber hat diese Benennung auf die ganze Zone des Nordatlantischen Ozeans in der Nähe von 30° N. Br. ausgedehnt, in der die Kalmen und Mallungen des absteigenden Luftstroms bei hohem Barometerstande gefunden werden.—Deutsche Seewarte, "Segelhandbuch für den Atlantischen Ozean," 2d ed., 1899, p. 3.

The present writer has also seen somewhere the suggestion that this name is derived from the French phrase *hors des alizés* ("outside the trade winds").

A recent letter from Mr. E. R. Miller, in charge of the Weather Bureau station at Madison, Wis., calls attention to the fact that Messrs. Linke and Clössner, in their "Wetterkundliche Unterricht" (Frankfurt a. M., 1911), page 112, have made a laughable blunder in attempting to explain the German term *Rossbreite*, which is, of course, merely the literal equivalent of "horse latitudes." The passage in question is as follows:

Die Gebiete des höchsten Luftdrucks liegen um 30° südlicher und nördlicher Breite. Diese beiden Gürtel hohen Druckes rund um die Erde führen nach dem Weltumsegler Ross den Namen "Rossbreiten."

SECTION VII.—WEATHER AND DATA FOR THE MONTH.

THE WEATHER OF THE MONTH.

P. C. DAY, Climatologist and Chief of Division.

[Dated: Weather Bureau, Washington, July 2, 1915.]

PRESSURE.

The distribution of the mean atmospheric pressure over the United States and Canada and the prevailing direction of the winds during May, 1915, are graphically shown on Chart VII, while the average values for the month at the several stations, with the departures from normal, are shown in Tables I and III.

For the month as a whole the barometric pressure was moderately high over Lake Superior and westward to the Dakotas, but over other portions of the country the means for the month were nearly everywhere below the normal. The greatest minus departures appear in the extreme eastern Canadian Provinces, and rather marked departures occurred in the New England and the North Pacific States and in the middle Mississippi and lower Ohio Valleys and thence southeasterly into the South Atlantic States.

The month opened with relatively low pressure over nearly all districts, except the extreme northeastern and the central Canadian Provinces where it was near or slightly above the normal, and pressure continued generally low over most districts until toward the end of the first decade, when an area of moderately high pressure moved from the far Southwest easterly to the Atlantic. During the second decade relatively low pressure again prevailed over most districts until near the middle of the month, when well-defined and rather extensive low and high pressure areas followed one another across the country with considerable regularity until early in the third decade, when the pressure again became low over most districts, which condition continued until after the middle of the decade, when several well-marked lows and highs again successively crossed the country. The month closed with relatively low pressure throughout all southern districts and in the extreme northern Rocky Mountain region; elsewhere relatively high pressure prevailed.

The distribution of the highs and lows was generally favorable for southerly winds over the west Gulf States and along the north Pacific coast, southwesterly over the coastal portion of the Southeastern States, and easterly to northeasterly over the upper Mississippi Valley, the Lake region, and portions of the Ohio Valley. Elsewhere variable winds prevailed.

TEMPERATURE.

May opened with low temperatures in the western Mountain districts, the Ohio Valley, and portions of the Gulf States, but in other districts there was some warming up, although the weather was still moderately cool. There were no specially marked changes in temperature until after the middle of the first week, when cooler weather overspread the central valleys and northern districts and extended into the eastern portions of the country with rather general light frost in portions of the Ohio Valley, the Lake region, and the North Atlantic States. By the end of the week the temperature had risen quite generally in the Lake region, Ohio Valley, and the districts to westward of the Mississippi, except in the northern Rocky Mountain region.

For the week as a whole the mean temperature was much below the normal in the central valleys and in the far Southwest, while over small areas along the Atlantic coast and in the far Northwest and over the upper Lake region the weekly means were above the normal.

There was a general tendency to warmer weather during the first few days of the second week, except that cooler weather overspread the upper Mississippi Valley, the Lake region, the Ohio Valley, and the northeastern districts. By the middle of the week it had become decidedly cooler over the Plateau and Rocky Mountain regions and in the Northeastern States, with heavy frost at points in New York and New England, but in the Middle West temperatures remained comparatively high. Toward the latter part of the week colder weather overspread most northern and central districts east of the Rocky Mountains, with temperatures near or below freezing in the upper Lake region and thence westward to the mountains, while in the far West there was a considerable warming up.

The mean temperature for the second week was below the normal in the eastern portion of the Pacific Coast States and eastward over the northern portion of the country to the Atlantic. Elsewhere it was near or above the normal, being quite high for the season in the central Plains States, portions of Kansas and Missouri, and thence southeastward to the Atlantic.

Cool weather continued over the northern and central districts at the beginning of the third week with a still further lowering of temperature in the middle Rocky Mountain and Great Plains regions. There was some warming up during the following few days, although the temperature continued generally below the normal in all parts of the country, except in portions of the South and in the Ohio Valley and Lake region, where it was somewhat higher, and considerably warmer weather overspread the districts to the eastward by the middle of the week. During the latter part of the week there was a tendency to warmer weather in nearly all districts, and at the close temperatures were still rising in the central valleys and were slightly above the normal elsewhere.

The mean temperature for the third week was below the normal in all portions of the country, save in the Gulf States and at points along the immediate Atlantic and Pacific coasts, it being unusually cold for the season from the Great Lakes westward to the Plateau region and in the great valley of California. However, in portions of the Gulf and South Atlantic States the week was distinctly warm, and along the Atlantic coast from the Carolinas northward temperature averages were near or slightly above the normal, and similar conditions prevailed along the Pacific coast.

At the beginning of the fourth week temperatures were rising in all districts, except in portions of the Atlantic Coast States and in the Northwest. However, during the following few days unusually cold weather for the season of the year overspread most eastern

districts, and temperatures near or slightly below freezing again occurred over much of the Lake region and at points in New York and New England. At the same time, cooler weather prevailed to the westward of the mountains, but in the central valleys and to the southward temperatures continued moderately high, with a tendency to cooler as the week advanced. During the latter portion of the week the temperatures continued very generally below the normal, but by its close they were generally rising and near the seasonal averages in most districts.

As during the preceding week, the average temperatures were decidedly below the normal over the greater part of the country. Over the interior valleys and portions of the Great Plains the averages were from 5° to 10° or more below the normal and the deficiencies were nearly as great in the Lake region and portions of the Atlantic Coast States. Over a small area in the Southern States and generally in California, Oregon, and Nevada and at a few points in the Northwest the weekly means were near or slightly above normal.

PRECIPITATION.

At the beginning of the month there was a general absence of precipitation, except in the far Southwest where some heavy local showers occurred, and during the first few days rain became fairly general in the Plains States, and snow fell at points in the middle Rocky Mountain region. By the middle of the first week local heavy rainfalls occurred in the Gulf States and Ohio Valley and lighter rains in nearly all other districts to eastward of the Mississippi. The last days of the week were comparatively free from rain, except locally in the Southeastern States and the far West, where beneficial showers occurred. The rainfall for the week was unusually widespread, no part of the country being without some rain, save in a small area from extreme western Texas and southern New Mexico to the lower Colorado Valley. Heavy rains occurred over the Gulf States to eastward of the Mississippi, thoroughly breaking the rather serious drought that had prevailed in that district, and there were again copious falls over much of Texas and thence northward over Oklahoma, Kansas, and Colorado, where the soil had been unusually wet for several weeks. There were some unseasonably late rains in California.

Early in the second week rains fell over nearly the entire Gulf and Atlantic Coast States, the falls being especially heavy in the Southeastern States, and they were generous in the Middle Atlantic States, where rain was much needed. By the middle of the week light rains had fallen from North Dakota westward to the coast and southward to the middle Plateau region. During the latter part of the week considerable precipitation occurred in the northern portions of the Missouri and upper Mississippi valleys and the Lake region, with light rains eastward to the Atlantic coast and in most sections to the westward of the Rocky Mountains, with some snow in southwestern Wyoming and western Nebraska. For the week as a whole the precipitation was generous to fairly heavy over most of the central and eastern portions of the cotton belt, and good amounts were received in the Atlantic Coast States, the Lake region, and thence westward along the northern border to the Pacific and also in the middle and north Pacific States. The week was practically rainless in the west Gulf States and the southern portions of the Mountain and Plateau districts, and but little precipitation occurred in the central Mountain region, the Plains States, and the Central Valleys.

The third week opened with light rains in most districts west of the Rocky Mountains, and by the middle of the week substantial amounts had occurred over much of the country surrounding the upper Mississippi Valley, portions of the Lake region, the Ohio Valley, and the Northeastern States. For the latter part of the week rains were more local in character, but good showers occurred over a large area from the central Plains eastward to the Atlantic coast, and light rains were fairly general in the far Northwest. The total precipitation for the week was generous from the middle Atlantic coast westward to the central Rocky Mountain region and thence northwestward to the Canadian border, the falls being unusually heavy in the Great Plains and middle Mississippi Valley. In the more northern districts, however, the falls were comparatively light, practically none occurring in portions of North Dakota and Montana, while over the Southern States there was likewise little rain save in North Carolina and thence westward to and including Oklahoma and portions of northern Texas.

At the beginning of the fourth week there was more or less rain over a wide area from the upper Mississippi Valley eastward, and during the next few days thundershowers were general from the middle Plains region eastward to the Ohio Valley. By the middle of the week there were thunderstorms with local heavy rains over much of the interior of the country. Some unusually heavy rains occurred in portions of the lower Missouri, middle Mississippi, and lower Ohio valleys, and floods resulted at many points in those districts. Local rains occurred during this period at points in the far Northwest and in the Gulf and South Atlantic States. During the closing days of the week there was a general decrease in the precipitation, but showers persisted in many districts, especially in the East Gulf and South Atlantic States. Over most districts east of the Rocky Mountains the week as a whole was cloudy and wet. The rainfall was heavy to excessive over practically the entire corn belt, in many portions of which the soil was saturated from the heavy rains of the preceding week. There were good rains over the northern Mountain and Plateau districts and in the far Northwest, but in most of the Lake region, the Middle and North Atlantic States, and the central and southern Mountain and Plateau districts the total falls for the week were generally small, while little or no rain occurred in the far Southwest, including California, and in portions of North Dakota and northern Minnesota.

A tornado visited Springfield, Mo., on May 20, at 6:25 p. m.

GENERAL SUMMARY.

The weather of May, 1915, was characterized by copious precipitation over large sections of the principal crop-producing areas, rain having fallen over practically every portion of the country except extreme southwestern Texas, the southern portions of New Mexico and Arizona, and southeastern California. The rainfall over portions of the Great Central Valleys, the South Atlantic and Gulf States, and along the north Pacific Coast was unusually heavy. Unseasonably cold weather accompanied the abundant rain, except in the South Atlantic and Gulf States and along the immediate Pacific coast, where the temperatures were generally above the normal. The weather was unusually cold throughout the central and northern portions of the country, with damaging frosts in some northern districts.

Average accumulated departures for May, 1915.

Districts.	Temperature.			Precipitation.			Cloudiness.		Relative humidity.	
	General mean for the current month.	Departure for the current month.	Accumulated departure since Jan. 1.	General mean for the current month.	Departure for the current month.	Accumulated departure since Jan. 1.	General mean for the current month.	Departure from the normal.	General mean for the current month.	Departure from the normal.
	°F.	°F.	°F.	In.	In.	In.	0-10.		P.ct.	P.ct.
New England	52.8	−1.7	+10.7	2.30	−1.00	−3.30	5.6	+0.1	71	−7
Middle Atlantic	60.0	−1.7	+ 8.1	3.18	−0.30	−1.60	5.9	+0.9	70	−2
South Atlantic	72.0	+2.2	− 1.0	5.93	+2.10	−1.90	4.9	+0.4	76	+2
Florida Peninsula	78.9	+1.2	−12.3	5.93	+1.70	+4.10	4.3	+0.1	79	+3
East Gulf	74.9	+2.6	− 5.8	6.21	+2.70	−2.30	4.9	+0.2	73	+2
West Gulf	72.3	+0.2	− 6.1	3.60	−0.60	+0.70	5.5	+0.7	75	0
Ohio Valley and Tennessee	63.5	−1.6	+ 0.7	4.69	+1.00	−4.90	6.7	+1.7	70	+2
Lower Lakes	52.9	−4.5	+ 3.6	4.62	−0.50	−3.50	6.2	+0.8	71	0
Upper Lakes	49.3	−3.3	+13.2	3.26	−0.20	−2.80	6.4	+0.9	73	+1
North Dakota	51.4	−2.8	+23.3	3.11	+0.60	−1.40	6.0	+0.5	65	+3
Upper Mississippi Valley	57.9	−4.0	+ 9.2	6.68	+2.50	+0.60	6.4	+1.1	74	+6
Missouri Valley	58.4	−3.6	+ 6.1	5.78	+1.50	+2.90	5.8	+0.7	72	+7
Northern slope	50.5	−2.5	+11.8	2.75	+0.40	+0.20	6.6	+1.1	67	+9
Middle slope	59.0	−3.8	− 0.4	4.49	+0.60	+3.60	5.1	+0.2	61	+6
Southern slope	68.2	−2.4	− 9.7	1.54	−1.20	+3.50	3.6	+0.8	57	−4
Southern Plateau	61.4	−4.5	−13.2	0.29	−0.10	+1.80	2.7	0.0	38	+6
Middle Plateau	54.0	−2.5	− 0.1	1.02	−0.20	+0.10	5.8	+1.7	53	+7
Northern Plateau	54.8	−2.1	+13.9	3.24	+1.50	+0.60	7.0	+1.9	63	+7
North Pacific	54.3	+1.2	+14.7	3.20	+0.60	−4.70	6.9	+0.6	78	+2
Middle Pacific	56.1	−1.4	+ 4.4	2.95	+1.60	+5.10	5.9	+1.9	75	+4
South Pacific	60.7	−0.9	+ 7.0	1.02	+0.40	+4.00	4.9	+0.8	73	+4

Maximum wind velocities, May, 1915.

Stations.	Date.	Velocity.	Direction.	Stations.	Date.	Velocity.	Direction.
		Mi./hr.				Mi./hr.	
Block Island, R. I.	26	50	nw.	New York, N. Y.	9	50	sw.
Buffalo, N. Y.	8	54	sw.	Do.	21	57	nw.
Cheyenne, Wyo.	14	52	w.	Do.	26	56	n.
Dallas, Tex.	30	54	s.	North Head, Wash.	10	52	se.
Denver, Colo.	14	50	nw.	Do.	24	56	se.
Detroit, Mich.	21	54	sw.	Oklahoma, Okla.	2	54	sw.
Jacksonville, Fla.	8	64	sw.	Pt. Reyes Light, Cal.	1	62	nw.
Little Rock, Ark.	23	50	s.	Do.	9	51	s.
Louisville, Ky.	7	56	se.	Do.	18	57	nw.
Do.	25	74	nw.	Do.	19	60	nw.
Modena, Utah	17	59	sw.	Do.	25	51	nw.
Mt. Tamalpais, Cal.	1	54	nw.	Do.	26	54	nw.
Do.	17	62	nw.	Do.	28	70	nw.
Do.	18	78	nw.	Do.	29	69	nw.
Do.	19	69	nw.	Do.	30	61	nw.
Do.	20	64	nw.	Do.	31	51	nw.
Do.	22	63	nw.	St. Paul, Minn.	14	62	se.
Do.	24	59	nw.	Sand Key, Fla.	12	60	w.
Do.	25	62	nw.	Sandy Hook, N. J.	26	58	nw.
Do.	26	54	nw.	Savannah, Ga.	26	52	se.
Do.	27	54	nw.	Sioux City, Iowa	2	55	se.
Do.	28	65	nw.	Do.	7	64	nw.
Do.	29	61	nw.	Do.	15	50	nw.
Do.	30	52	nw.	Toledo, Ohio	7	50	w.
Do.	31	78	nw.	Do.	8	51	sw.
New York, N. Y.	8	50	sw.	Do.	21	61	sw.

CONDENSED CLIMATOLOGICAL SUMMARY.

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data, as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course the number of such records is smaller than the total number of stations.

Summary of temperature and precipitation, by sections, May, 1915.

Section.	Temperature (° F.).								Precipitation (in inches and hundredths).					
	Section average.	Departure from the normal.	Monthly extremes.						Section average.	Departure from the normal.	Greatest monthly.		Least monthly.	
			Station.	Highest.	Date.	Station.	Lowest.	Date.			Station.	Amount.	Station.	Amount.
Alabama	74.5	+3.2	Troy	100	25	2 stations	42	6†	6.34	+2.31	Robertsdale	11.01	Madison	2.63
Arizona	63.3	−3.6	Sentinel	108	14	Fort Valley	6	3	0.44	+0.09	Flagstaff	2.20	14 stations	0.00
Arkansas	69.9	+0.3	Portland	101	14	Dutton	34	8†	5.58	+0.54	Fayetteville	11.15	Springbank	1.08
California	57.6	−4.5	Greenland Ranch	113	31	Fordyce Dam	2	2	4.13	+2.91	Magalia	19.63	5 stations	0.00
Colorado	49.1	−3.0	2 stations	99	13†	Hermit	−2	3†	2.63	+0.98	Julesburg	7.98	Saguache	0.60
Florida	78.3	+2.6	3 stations	100	16†	Orange City	52	3	6.10	+2.32	Garniers (near)	11.29	Ritta	1.97
Georgia	74.7	+2.9	Statesboro	102	26	Blue Ridge	40	10	6.76	+3.29	Glennville	12.61	Poulan	3.79
Hawaii (April)	70.1	......	2 stations	90	6†	Volcano House	46	25	10.47	......	Kopiliula, Maui	47.86	Waianae, Maui	0.35
Idaho	51.4	−1.6	Glenns Ferry	91	8†	Pierson	18	3	4.13	+1.78	Castle Creek	8.87	Glenns Ferry	1.42
Illinois	59.9	−2.9	Equality	97	14	La Harpe	28	9	6.97	+2.96	Casey	11.57	Pontiac	3.69
Indiana	59.6	−1.9	Vincennes	94	15	Auburn	29	19	5.93	+1.88	Princeton	9.97	Connorsville	3.08
Iowa	56.1	−4.4	Clarinda	99	14	2 stations	25	9	7.34	+2.77	Afton	13.21	Alton	3.82
Kansas	60.3	−3.5	2 stations	96	14†	3 stations	27	7†	7.10	+3.02	Oskaloosa	13.10	Coldwater	3.35
Kentucky	65.2	−0.5	Bowling Green	95	3	Berea	35	18	6.62	+2.70	Bowling Green	8.89	Pikeville	3.94
Louisiana	75.2	+1.2	2 stations	101	20†	St. Gabriel	42	6	5.08	+0.69	Vinton	17.14	Dodson	1.01
Maryland and Delaware	60.9	−2.3	Cambridge, Md	90	22	Deer Park, Md	25	2	3.83	+0.39	Oakland, Md	6.34	Washington, D. C	2.18
Michigan	50.5	−3.5	Alma	85	11	Humboldt	19	27	2.99	−0.28	Victoria	5.77	Traverse City	0.76
Minnesota	51.5	−3.3	Farmington	93	12	2 stations	20	10†	4.13	−0.75	Albert Lea	8.72	Two Harbors	0.31
Mississippi	73.6	+1.5	3 stations	98	25†	2 stations	43	8†	5.79	+1.42	Edenburg	10.55	Clarksdale	1.59
Missouri	63.7	−1.4	Steffenville	97	12†	Bethany	30	9	7.86	+3.04	Lexington	15.98	Sikeston	3.04
Montana	50.3	−1.2	Saco	90	9	Medicine Lake	14	8	2.71	+0.18	Dillon	5.18	Lothair	0.60
Nebraska	55.8	−3.4	Tekamah	102	13	Cambridge	20	21	5.25	+1.65	Tekamah	10.80	Mitchell	1.96
Nevada	53.2	−2.0	Logan	103	31	Lida	12	1	1.34	+0.35	Jack Creek	5.45	Searchlight	0.13
New England	52.8	−2.4	Durham, N. H	86	22†	Greenville, Me	22	27	2.22	−1.18	Van Buren, Me	5.14	Grafton, N. H	0.61
New Jersey	58.1	−2.2	2 stations	88	22†	2 stations	30	16†	3.82	−0.03	Haddonfield	6.15	Asbury Park	2.00
New Mexico	56.7	−3.2	Artesia	101	16	Luna	16	3	0.97	−0.04	Valley	7.30	19 stations	0.00
New York	51.8	−4.1	Bedford	85	7	Salisbury	21	27	2.59	−0.99	Morehouseville	4.58	Harkness	1.14
North Carolina	67.9	+0.8	3 stations	96	16	Banners Elk	32	10	5.63	+1.58	Rock House	8.90	Beaufort	2.24
North Dakota	51.2	−1.9	Cando	98	27	2 stations	15	6†	3.16	+0.59	Mott	5.00	Lakota	1.14
Ohio	57.8	−3.3	Portsmouth	89	14	2 stations	2	18†	3.99	+0.18	Wilmington	9.79	Youngstown	1.89
Oklahoma	65.8	−1.7	Newkirk	98	15	Hurley	25	7	6.01	+0.37	Newkirk	11.35	Goodwell	2.45
Oregon	52.9	−0.4	Umatilla	95	8†	Beckley	10	2	3.41	+1.20	Cascadia	9.97	Grass Valley	0.54
Pennsylvania	56.2	−3.7	Lancaster	84	22	West Bingham	21	27	4.16	+0.53	California	7.45	New Castle	2.29
Porto Rico	78.0	+0.9	Juana Diaz	99	21	3 stations	54	4†	5.24	−2.06	Rio Grande	13.45	Josefa	0.45
South Carolina	73.0	+1.5	2 stations	98	15	Yemassee	46	6	7.20	+3.69	Maysville (near)	15.55	Darlington	4.02
South Dakota	52.0	−4.2	Winner	95	12	Rosebud	18	18	3.63	+0.34	Cottonwood	6.91	Bryant	1.71
Tennessee	69.2	+2.2	Arlington	100	25	Rugby	34	10	5.66	+1.51	Johnsonville	8.73	Kingston	2.59
Texas	72.7	−0.3	Encinal	108	25	Dalhart	29	7	2.47	−1.36	Orange	11.41	3 stations	0.00
Utah	52.6	−1.6	Beaver	98	12	Ranch	5	3	1.99	+0.67	Richmond	4.81	Hayden	0.01
Virginia	63.6	−0.4	Callaville	91	16†	Burkes Garden	30	10	3.30	−0.74	Diamond Springs	5.28	Quantico	1.10
Washington	55.0	0.0	Eltopia	92	8	Cle Elum	26	4	3.22	+0.70	Quiniault	12.40	Eltopia	0.15
West Virginia	61.1	−1.4	Powellton	92	20	Bayard	29	2†	4.22	+0.38	Rowlesburg	6.85	Central Station	2.56
Wisconsin	50.6	−4.4	Hayward	91	12	Long Lake	18	19	4.95	+1.14	Menominee Falls	8.37	Plum Island	2.41
Wyoming	45.8	−2.0	Fort Laramie	90	13	Dome Lake	0	6	2.94	+0.73	Dome Lake	7.99	Hyattville	0.22

† Other dates also.

DESCRIPTION OF TABLES AND CHARTS.

Table I gives the data ordinarily needed for climatological studies for about 158 Weather Bureau stations making simultaneous observations at 8 a. m. and 8 p. m., daily, 75th meridian time and for about 41 others making only one observation. The altitudes of the instruments above ground are also given.

Table II gives a record of precipitation, the intensity of which at some period of the storm's continuance equaled or exceeded the following rates:

Duration (minutes)	5	10	15	20	25	30	35	40	45	50	60
Rates per hour (inches)	3.00	1.80	1.40	1.20	1.08	1.00	0.94	0.90	0.87	0.84	0.80

It is impracticable to make this table sufficiently wide to accommodate on one line the record of accumulated falls that continue at an excessive rate for several hours. In this case *the record is broken at the end of each 50 minutes*, the accumulated amounts being recorded on successive lines until the excessive rate ends.

In cases where no storm of sufficient intensity to entitle it to a place in the full table has occurred, the greatest precipitation of any single storm has been given, also the greatest hourly fall during that storm.

The tipping-bucket mechanism is *dismounted* and removed when there is danger of snow or water freezing in the same. Table II records this condition by entering an asterisk(*).

Table III gives, for about 30 stations of the Canadian Meteorological Service, the means of pressure and temperature, total precipitation and depth of snowfall, and the respective departures from normal values except in the case of snowfall.

Chart I.—Hydrographs for several of the principal rivers of the United States.

Chart II.—Tracks of centers of high areas; and

Chart III.—Tracks of centers of low areas. The roman numerals show the chronological order of the centers. The figures within the circles show the days of the month; the letters *a* and *p* indicate, respectively, the observations at 8 a. m. and 8 p. m., 75th meridian time. Within each circle is also given (Chart II) the last three figures of the highest barometric reading and (Chart III) the lowest reading reported at or near the center at that time, and in both cases as reduced to sea level and standard gravity.

Chart IV.—Temperature departures. This chart presents the departures of the monthly mean temperatures from the monthly normals. The normals used in computing the departures were computed for a period of 33 years (1873 to 1905) and are published in Weather Bureau Bulletin "R," Washington, 1908. Stations whose records were too short to justify the preparation of normals in 1908 have been provided with normals as adequate records became available and all have been reduced to the 33-year interval, 1873–1905. The shaded portions of the chart indicate areas of positive departures and unshaded portions indicate areas of negative departures. Generalized lines connect places having approximately equal departures of like sign. This chart of monthly temperature departures in the United States was first published in the MONTHLY WEATHER REVIEW for July, 1909.

Chart V.—Total precipitation. The scale of shades showing the depth is given on the chart. Where the monthly amounts are too small to justify shading, and over sections of the country where stations are too widely separated or the topography is too diversified to warrant reasonable accuracy in shading, the actual depths are given for a limited number of representative stations. Amounts less than 0.005 inch are indicated by the letter T, and no precipitation by 0.

Chart VI.—Percentage of clear sky between sunrise and sunset. The average cloudiness at each Weather Bureau station is determined by numerous personal observations between sunrise and sunset. The difference between the observed cloudiness and 100 is assumed to represent the percentage of clear sky, and the values thus obtained are the basis of this chart. The chart does not relate to the nighttime.

Chart VII.—Isobars and isotherms at sea level and prevailing wind directions. The pressures have been reduced to sea level and standard gravity by the method described by Prof. Frank H. Bigelow on pages 13–16 of the REVIEW for January, 1902. The pressures have also been reduced to the mean of the 24 hours by the application of a suitable correction to the mean of the 8 a. m. and 8 p. m. readings at stations taking two observations daily, and to the 8 a. m. or the 8 p. m. observation, respectively, at stations taking but a single observation. The diurnal corrections so applied will be found in the Annual Report of the Chief of the Weather Bureau, 1900–1901, volume 2 Table 27, pages 140–164.

The isotherms on the sea-level plane have been constructed by means of the data summarized in chapter 8 of volume 2, of the annual report just mentioned. The correction t_0-t, or temperature on the sea-level plane minus the station temperature as given by Table 48 of that report, is added to the observed surface temperature to obtain the adopted sea-level temperature.

The prevailing wind directions are determined from hourly observations at the great majority of the stations; a few stations having no self-recording wind direction apparatus determine the prevailing direction from the daily or twice-daily observations only.

Chart VIII.—Total snowfall. This is based on the reports from regular and cooperative observers and shows the depth in inches and tenths of the snowfall during the month. In general, the depth is shown by lines inclosing areas of equal snowfall, but in special cases figures are also given. Chart VIII is published only when the general snow cover is sufficiently extensive to justify its preparation.

TABLE I.—*Climatological data for United States Weather Bureau stations, May, 1915.*

Districts and stations.	Elevation of instruments.			Pressure in inches.			Temperature of the air, in degrees Fahrenheit.										Mean wet thermometer.	Mean temperature of the dew point.	Mean relative humidity, per cent.	Precipitation, inches.			Wind.						Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow on ground at end of month.
	Barometer above sea level, feet.	Thermometer above ground.	Anemometer above ground.	Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Mean max.+mean min.÷2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.				Total.	Departure from normal.	Days with 0.01 or more.	Total movement, miles.	Prevailing direction.	Maximum velocity: Miles per hour.	Maximum velocity: Direction.	Maximum velocity: Date.						
New England.							**52.8**	**-1.7**											**71**	**2.30**	**-1.0**										**5.6**		
Eastport	76	67	85	29.74	29.82	-0.14	46.6	-0.3	69	23	54	33	27	40	29	43	39	78	3.14	-0.7	11	7,433	s.	48	ne.	1	6	10	15	7.0	0.1	
Greenville	1,070	6		28.69	29.85		47.6		79	12	58	22	27	37	41				2.99		13										3.0	
Portland, Me.	103	82	117	29.76	29.88	-.09	52.2	-1.3	81	12	61	35	27	44	35	46	39	63	2.05	-1.6	9	7,438	nw.	36	nw.	28	12	4	15	5.5		
Concord	288	70	79	29.57	29.88	-.10	52.6	-3.1	78	12	65	32	15	41	41				0.99	-2.2	9	4,538	nw.	31	nw.	28	14	7	10	4.5		
Burlington	404	11	48	29.46	29.90	-.07	51.2	-2.7	78	12	61	33	30	42	32				1.73	-1.1	10	7,258	nw.	40	s.	22	4	17	10	5.9		
Northfield	876	12	60	28.96	29.91	-.06	47.6	-5.9	76	12	60	27	30	35	42	44	38	67	1.56	-1.2	14	5,831	s.	34	s.	7	8	9	14	6.2		
Boston	125	115	188	29.75	29.89	-.09	56.6	0.0	80	22	65	39	27	48	28	50	43	63	1.64	-1.9	9	7,836	w.	31	nw.	13	13	7	11	4.8		
Nantucket	12	14	90	29.88	29.89	-.10	52.6	-0.4	70	7	59	41	30	46	21	48	45	81	4.01	+1.3	12	10,704	sw.	42	n.	26	9	14	8	5.4		
Block Island	26	11	46	29.87	29.90	-.09	52.8	-0.1	66	11	58	41	2	47	19	50	48	86	3.11	-0.6	12	11,420	sw.	50	nw.	26	10	9	12	5.5		
Narragansett Pier		9					53.4	-1.3	72	9	62	38	27	45	30				3.10		12		sw.				16	8	7			
Providence	160	215	251	29.72	29.89	-.09	55.8	-2.7	75	9	65	39	27	47	29	49	42	64	1.82	-1.6	10	10,087	nw.	48	nw.	26	9	12	10	5.2		
Hartford	159	122	140	29.73	29.91	-.07	55.8	-1.3	78	31	66	39	27	46	36	49	43	66	2.53	-1.0	11	5,570	nw.	29	se.	29	9	9	13	5.7		
New Haven	106	117	155	29.80	29.91	-.08	56.7	-0.9	76	11	66	40	27	48	32	50	44	67	2.72	-0.9	13	6,409	nw.	36	nw.	26	9	8	14	5.7		
Middle Atlantic States.							**60.0**	**-1.7**											**70**	**3.18**	**-0.3**										**5.9**		
Albany	97	102	115	29.80	29.90	-.08	54.8	-4.1	77	31	64	38	27	46	33	48	41	63	1.92	-1.1	12	5,605	s.	29	s.	7	12	6	13	5.1		
Binghamton	871	10	69	28.99	29.93	-.05	52.6	-4.4	76	31	62	34	16	43	35				2.31	-0.8	14	3,668	nw.	22	nw.	26	6	7	18	6.8		
New York	314	414	454	29.58	29.91	-.08	57.7	-1.6	76	22	65	41	27	50	26	50	43	62	3.23	0.0	12	11,279	nw.	57	nw.	21	8	9	14	6.3		
Harrisburg	374	94	104	29.55	29.94	-.04	58.4	-3.3	77	8	67	41	27	50	26	51	45	64	2.84	-0.8	13	2,815	e.	20	nw.	5	6	10	15	6.6		
Philadelphia	117	123	190	29.82	29.94	-.05	60.9	-1.3	81	22	69	44	27	53	25	54	49	69	4.12	+0.9	13	7,058	nw.	40	n.	26	10	5	16	6.0		
Reading	325	81	98	29.59	29.94		58.3		78	8	67	41	27	49	32	51	44	63	3.46	+0.1	12	4,789	nw.	29	nw.	26	6	8	17	6.8		
Scranton	805	111	119	29.08	29.94	-.04	54.6	-4.2	76	11	64	37	15	46	33	49	43	66	3.30	-0.1	16	4,629	nw.	24	se.	7	5	10	16	6.6		
Atlantic City	52	37	48	29.88	29.94	-.04	58.1	+0.6	79	23	65	44	27	51	24	53	49	75	3.21	+0.2	12	5,888	sw.	29	s.	7	6	11	14	6.5		
Cape May	18	13	49	29.94	29.96	-.03	59.0	+0.4	79	23	66	43	27	52	20				3.33	+0.3	13	6,183	s.	30	e.	30	9	14	8	5.3		
Sandy Hook	22	10	57	29.90	29.92		58.0		77	22	65	46	1	51	24	55	54	93	3.15		14	9,739	w.	58	nw.	26	11	8	12	5.7		
Trenton	190	159	183	29.72	29.92		58.4		79	22	67	42	27	50	30	52	46	67	4.33	+0.8	13	7,343	w.	37	w.	9	10	7	14	6.2		
Baltimore	123	100	113	29.81	29.94	-.05	62.2	-2.0	85	22	70	43	27	54	28	55	49	67	3.19	-0.4	14	4,876	n.	30	n.	26	6	12	13	6.2		
Washington	112	62	85	29.80	29.92	-.08	62.5	-1.7	86	22	72	42	27	53	32	54	49	65	2.18	-1.6	11	4,333	nw.	28	nw.	22	7	12	12	6.3		
Lynchburg	681	153	188	29.18	29.92	-.08	65.4	-0.5	90	16	76	44	18	55	31	58	55	73	1.99	-2.0	10	5,513	e.	41	nw.	23	2	21	8	6.2		
Norfolk	91	170	205	29.84	29.94	-.06	66.0	-0.2	88	16	74	47	28	58	32	59	55	74	4.82	+0.8	14	9,251	se.	42	s.	7	8	14	9	5.7		
Richmond	144	11	52	29.78	29.93	-.06	66.0	-1.3	89	16	76	47	18	56	31	58	54	72	3.00	-0.8	11	5,843	s.	30	ne.	27	12	10	9	5.0		
Wytheville	2,293	40	47	27.59	29.92	-.07	61.2	-0.2	84	23	72	38	10	50	37	55	52	75	3.64	-0.4	16	4,081	w.	26	w.	22	18	10	3	3.6		
South Atlantic States.							**72.0**	**+2.2**											**76**	**5.93**	**+2.1**										**4.9**		
Asheville	2,255	70	84	27.62	29.92	-.07	63.8	+1.2	85	15	74	46	10	54	33	57	53	73	4.53	+0.8	17	6,059	nw.	42	e.	11	9	16	6	4.9		
Charlotte	773	152	161	29.07	29.90	-.09	69.3	+0.9	89	16	78	53	20	61	26	62	57	72	5.47	+1.6	15	7,282	ne.	36	nw.	7	3	17	11	6.9		
Hatteras	11	12	50	29.92	29.93	-.08	68.3	+1.2	83	23	74	54	27	63	19	64	62	83	4.51	+0.4	15	10,475	sw.	47	ne.	27	6	17	8	6.2		
Manteo	12	4	46				67.0		92	16	76	37	28	58					6.47		10						11	13	7			
Raleigh	376	103	110	29.52	29.92	-.07	69.0	+0.9	91	16	78	52	31	60	28	61	57	72	4.40	-0.5	18	5,650	sw.	34	w.	4	9	11	11	6.0		
Wilmington	78	81	91	29.85	29.93	-.08	71.9	+2.8	94	16	80	55	28	64	25	66	63	81	3.59	-0.4	13	6,380	sw.	28	ne.	27	7	15	9	5.7		
Charleston	48	11	92	29.88	29.93	-.08	75.5	+3.1	96	16	82	60	6	69	23	69	66	78	8.92	+5.4	10	8,064	sw.	46	ne.	27	11	8	12	5.5		
Columbia, S. C.	351	41	57	29.55	29.92	-.08	73.1	+1.3	93	26	83	56	10	64	29	65	60	70	5.62	+2.4	15	4,955	sw.	34	sw.	29	9	12	10	6.0		
Augusta	180	89	97	29.73	29.92	-.07	75.0	+2.8	94	15	84	57	6	66	29	67	62	70	7.46	+4.2	12	4,811	w.	39	nw.	7	9	10	12	6.0		
Savannah	65	150	194	29.86	29.93	-.07	76.4	+3.9	97	26	85	60	6	68	26	70	68	84	11.13	+8.1	15	8,943	sw.	52	se.	26	9	10	12	5.9		
Jacksonville	43	209	245	29.90	29.95	-.05	77.8	+3.6	95	25	86	62	13	70	27	70	67	78	3.67	-0.6	13	8,634	sw.	64	sw.	8	7	12	12	6.1		
Florida Peninsula.							**78.9**	**+1.2**											**79**	**5.93**	**+1.7**										**4.3**		
Key West	22	10	64	29.91	29.93	-.04	80.1	+1.1	89	29	86	68	2	75	16	74	72	77	7.61	+4.2	10	6,400	se.	39	sw.	13	17	12	2	3.4		
Miami	25	71	79	29.93	29.96		78.0	-0.6	87	29	83	64	1	73	18	73	71	78	3.32	-3.0	7	6,562	se.	24	ne.	31	8	14	9	5.5		
Sand Key	23	39	72	29.89	29.92	-0.5	78.9		88	29	82	69	12	76	19	75	74	84	4.12		8	7,863	se.	60	w.	12	20	8	3	3.0		
Tampa	35	79	96	29.91	29.94	-0.5	78.7	+3.2	92	16	87	65	3	70	23	72	69	76	6.87	+4.0	8	4,909	sw.	44	s.	9	9	13	9	5.2		
East Gulf States.							**74.9**	**+2.6**											**73**	**6.21**	**+2.7**										**4.9**		
Atlanta	1,174	190	216	28.71	29.93	-.06	71.5	+2.0	91	26	81	54	28	62	26	63	59	71	6.11	+3.0	10	7,860	w.	42	nw.	30	10	11	10	5.6		
Macon	370	78	87	29.52	29.91	-.08	76.0	+4.9	95	26	86	56	6	66	30	67	63	72	4.94	+2.1	10	4,339	se.	24	s.	7	10	13	8	5.2		
Thomasville	273	8	57	29.63	29.92	-.07	77.8	+3.8	98	25	89	56	6	67	33	69	66	78	8.75	+4.7	12	3,946	sw.	25	sw.	7	12	10	9	5.1		
Pensacola	56	140	182	29.85	29.91	-.08	75.8	+1.0	89	16	82	61	11	70	21	70	68	79	9.92	+7.2	8	9,374	sw.	44	sw.	11	13	9	9	5.1		
Anniston	741	9	57	29.14	29.92	-.07	72.5	+4.1	92	26	84	50	5	61	30				5.85	+2.8	10	4,232	w.	31	n.	7	14	12	5	4.4		
Birmingham	700	11	48	29.17	29.92	-.06	73.1	+1.5	93	26	82	52	10	64	28	65	61	70	6.14	+3.0	7	4,847	s.	36	se.	6	8	17	6	5.3		
Mobile	57	125	161	29.84	29.90	-.09	76.2	+2.6	92	14	84	61	12	68	26	69	66	76	4.67	+0.7	9	7,155	sw.	38	se.	6	15	12	4	4.3		
Montgomery	223	100	112	29.67	29.91	-.08	76.6	+3.1	96	25	86	60	10	67	28	67	63	69	7.42	+3.6	10	4,658	s.	30	w.	27	15	8	8	4.1		
Meridian	375	85	93	29.50	29.89	-.09	73.2	+2.1	94	25	83	54	13	63	30	66	63	74	6.90	+3.0	9	3,807	sw.	34	se.	6	15	9	7	4.8		
Vicksburg	247	65	74	29.62	29.90	-.07	73.8	+0.9	90	26	83	57	8	65	26	66	62	72	3.96	-0.3	10	5,108	s.	33	nw.	27	11	11	9	5.1		
New Orleans	51	76	84	29.85	29.90	-.07	77.4	+2.9	93	25	86	61	7	69	23	69	66	74	3.64	-0.2	9	5,085	sw.	36	nw.	7	12	12	7	4.4		
West Gulf States.							**73.2**	**+0.2**											**75**	**3.60**	**-0.6**										**5.5**		
Shreveport	249	77	93	29.61	29.87	-.08	74.6	+1.4	92	14	84	55	8	65	32	66	61	68	1.81	-2.4	5	5,803	s.	29	e.	27	11	8	12	5.3		
Bentonville	1,303	11	44	28.49	29.84	-.09	64.7	+1.7	88	13	75	41	9	54	32				10.12	+4.9	14	4,031	s.	25	w.	20	10	8	13	5.8		
Fort Smith	457	79	94	29.37	29.84	-.09	69.6	-0.1	92	14	80	46	8	60	31	62	58	73	6.65	+1.7	13	5,816	e.	43	se.	21	9	6	16	6.0		
Little Rock	357	139	147	29.50	29.86	-.09	70.4	0.0	91	14	80	47	8	61	30	63	60	73	4.38	-0.7	11	6,969	s.	50	s.	23	11	13	7	4.8		
Brownsville	57	3	40				78.8		97	30	88	58	9	70	30				0.50		3		s.	40			31					
Corpus Christi	20	69	77	29.82	29.83	-.07	76.0	-0.5	86	13	81	62	12	71	23	71	69	84	3.22	+0.4	5	11,540	se.	46	nw.	31	5	14	12	6.2		
Dallas	512	109	117	29.30	29.84		73.2		92	29	83	50	8	64	31				1.73		9	7,515	se.	54	s.	30	9	10	12	5.8		
Fort Worth	670	106	114	29.12	29.82	-.09	72.7	-0.5	92	29	82	48	7	63	34	64	59	68	2.49	-1.7	10	7,786	s.	42	nw.	29	10	4	17	5.8		
Galveston	54	106	114	29.82	29.88	-.06	75.5	+0.1	85	12	80	64	8	71	17	70	67	81	2.70	-0.5	6	9,613	s.	48	w.	30	10	16	5	4.6		
Houston	138	111	121	29.72	29.86		75.9	+0.4	90	14	84	57	8	68	26				1.39		7	7,110	se.	30	sw.	30	10	13	8	5.0		
Palestine	510	64	72	29.32	29.84	-.09	73.3	+0.8	90	26	82	53	8	64	28	67	64	78	1.51	-3.4	9	5,695	s.	37	w.	27	10	8	13	5.6		
San Antonio	701	109	132	29.10	29.82	-.08	75.6	+0.8	91	24	85	56	11	66	28	67	63	73	1.89	-1.1	12	6,400	s.	35	se.	4	8	19	4	5.3		
Taylor	582	55	63	29.26	29.87	-.04	74.4	+0.1	92	24	84	53	8	65	30				1.27	-2.7	6	7,381	se.	34	nw.	30	9	13	9	5.5		

TABLE I.—*Climatological data for United States Weather Bureau stations, May, 1915*—Continued.

Districts and stations.	Elevation of instruments. Barometer above sea level, feet.	Thermometer above ground.	Anemometer above ground.	Pressure in inches. Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Temperature of the air, in degrees Fahrenheit. Mean max.+mean min.÷2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.	Mean wet thermometer.	Mean temperature of the dew point.	Mean relative humidity, per cent.	Precipitation, inches. Total.	Departure from normal.	Days with 0.01 or more.	Wind. Total movement, miles.	Prevailing direction.	Maximum velocity. Miles per hour.	Direction.	Date.	Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow on ground at end of month.
Ohio Valley and Tennessee.							**63.5**	**− 1.6**										**70**	**4.69**	**+ 1.0**										**6.7**		
Chattanooga	762	189	213	29.13	29.92	−0.07	71.0	+ 2.4	91	15	80	52	10	61	28	62	57	67	4.62	+ 1.0	15	6,331	ne.	32	nw.	17	7	17	7	5.6	....	....
Knoxville	996	93	100	28.87	29.91	− .08	69.0	+ 2.5	91	15	80	49	5	59	32	61	56	68	3.59	− 0.1	17	4,236	sw.	30	n.	25	5	14	12	6.3	....	....
Memphis	399	76	97	29.49	29.90	− .06	71.2	+ 0.5	90	26	80	53	8	63	27	63	59	70	5.70	+ 1.4	11	6,592	sw.	44	nw.	23	7	14	10	5.9	....	....
Nashville	546	168	191	29.34	29.91	− .07	70.1	+ 1.3	91	15	80	45	10	60	28	61	56	68	4.94	+ 1.4	9	7,272	w.	46	nw.	22	9	10	12	5.5	....	....
Lexington	989	75	102	28.84	29.89	− .10	62.4	− 1.9	87	15	71	41	18	54	29	....	....	....	7.23	+ 3.7	16	7,196	e.	43	nw.	25	7	9	15	6.2	....	....
Louisville	525	219	255	29.34	29.92	− .06	64.2	− 2.5	89	15	73	46	18	55	29	58	55	75	4.62	+ 1.0	16	8,294	se.	74	nw.	25	5	8	18	7.1	....	....
Evansville	431	72	82	29.42	29.89	− .08	65.2	− 1.9	89	13	74	45	10	56	32	59	55	73	7.96	+ 4.5	20	5,792	ne.	44	sw.	3	6	10	15	6.6	....	....
Indianapolis	822	154	164	29.02	29.90	− .07	59.7	− 3.6	82	15	69	42	1	51	29	53	48	69	3.94	0.0	18	7,658	e.	42	sw.	8	1	11	19	7.6	....	....
Terre Haute	575	96	129	29.27	29.88	....	61.2	....	89	15	70	43	10	52	31	55	51	73	6.23	....	16	7,250	e.	45	nw.	25	2	14	15	7.3	....	....
Cincinnati	628	11	51	29.24	29.91	− .08	60.2	− 4.9	82	21	70	38	10	50	31	55	51	74	5.56	+ 2.0	21	5,410	ne.	30	sw.	21	3	9	19	7.5	....	....
Columbus	824	173	222	29.05	29.92	− .06	58.2	− 3.1	82	21	68	39	27	49	30	52	47	69	2.57	− 1.2	14	8,191	e.	45	w.	4	1	9	21	7.7	....	....
Dayton	899	181	216	28.94	29.89	....	58.8	− 4.1	82	21	68	39	18	49	30	53	49	73	4.76	+ 0.9	16	7,152	ne.	45	se.	7	8	10	13	5.9	....	....
Pittsburgh	842	353	410	29.02	29.92	− .07	58.0	− 4.6	81	21	67	40	27	49	30	51	45	64	3.84	+ 0.5	15	7,899	w.	46	w.	4	4	9	18	7.3	....	....
Elkins	1,940	41	50	27.90	29.92	− .07	58.8	− 0.3	82	21	70	35	11	48	39	52	47	70	2.86	− 1.1	16	3,114	w.	25	w.	4	2	10	19	7.5	....	....
Parkersburg	638	77	84	29.28	29.94	− .05	61.6	− 1.7	86	21	71	40	10	52	32	55	50	70	3.47	0.0	16	4,090	n.	44	nw.	21	6	11	14	6.8	....	....
Lower Lake Region.							**52.9**	**− 4.5**										**71**	**2.62**	**− 0.5**										**6.2**		
Buffalo	767	247	280	29.10	29.93	− .04	51.1	− 3.4	73	11	58	36	19	44	26	46	42	74	1.86	− 1.2	13	11,442	sw.	54	sw.	8	7	10	14	6.4	T.	....
Canton	448	10	61	29.44	29.92	....	50.7	− 5.5	75	12	60	30	16	41	32	....	....	....	1.57	− 1.3	14	8,263	w.	44	sw.	9	13	7	11	4.8	....	....
Oswego	335	76	91	29.55	29.92	− .05	50.2	− 4.5	75	12	57	35	10	43	26	45	40	69	1.38	− 1.5	11	6,822	w.	28	s.	7	11	9	11	5.4	....	....
Rochester	523	97	113	29.37	29.95	− .02	52.6	− 4.1	78	12	61	36	19	44	27	47	40	64	2.10	− 0.8	10	6,263	w.	30	w.	8	11	4	16	5.9	....	....
Syracuse	597	97	113	29.29	29.94	− .04	52.0	− 5.3	73	12	60	37	27	44	27	46	40	66	2.02	− 1.4	10	7,530	w.	38	s.	7	9	6	16	6.1	....	....
Erie	714	130	166	29.16	29.93	− .05	53.7	− 3.6	76	21	61	39	27	46	24	48	44	72	3.20	− 0.2	10	9,336	ne.	48	sw.	21	5	14	12	6.2	....	....
Cleveland	762	190	201	29.11	29.93	− .05	54.2	− 4.3	79	21	61	39	18	47	23	49	44	73	3.13	− 0.1	12	8,821	ne.	46	n.	26	3	17	11	6.6	....	....
Sandusky	629	62	103	29.24	29.92	− .06	54.8	− 4.4	81	21	62	37	18	48	25	50	45	72	3.00	− 0.2	16	9,121	e.	40	w.	8	5	10	16	6.7	....	....
Toledo	628	208	243	29.25	29.93	− .04	54.8	− 4.9	82	12	63	37	19	46	28	50	46	74	4.27	+ 1.0	15	10,919	ne.	61	sw.	21	8	13	10	5.8	....	....
Fort Wayne	856	113	124	29.00	29.92	....	55.2	− 5.0	81	12	65	35	5	46	29	50	46	72	4.60	....	16	7,462	ne.	44	sw.	21	4	6	21	7.3	....	....
Detroit	730	218	245	29.14	29.94	− .03	53.0	− 4.9	79	12	62	35	27	44	28	47	42	70	3.69	+ 0.4	16	9,050	e.	54	sw.	21	4	12	15	6.7	....	....
Upper Lake Region.							**49.3**	**− 3.3**										**73**	**3.26**	**− 0.2**										**6.4**		
Alpena	609	13	92	29.28	29.95	− .02	48.6	− 0.9	74	11	57	29	18	40	34	44	38	68	1.78	− 1.6	7	8,621	se.	40	se.	7	4	17	10	6.1	T.	....
Escanaba	612	54	60	29.28	29.94	− .03	47.6	− 2.4	70	31	55	28	18	40	26	48	37	70	2.54	− 0.9	10	7,753	n.	33	ne.	18	8	8	15	6.1	T.	....
Grand Haven	632	54	92	29.23	29.91	− .05	50.6	− 4.2	73	31	59	34	19	42	31	46	40	72	2.94	− 0.4	17	8,491	e.	34	sw.	7	10	12	9	5.5	T.	....
Grand Rapids	707	70	87	29.16	29.93	− .04	53.3	− 5.7	81	12	63	34	18	44	30	47	41	67	2.61	− 0.7	13	5,364	e.	26	w.	21	6	11	14	6.8	0.2	....
Houghton	684	62	72	29.22	29.95	− .02	46.2	− 3.5	83	11	55	30	19	38	45	....	....	....	3.61	+ 0.3	15	6,642	e.	42	w.	11	9	10	12	5.8	0.3	....
Lansing	878	11	62	28.98	29.93	....	51.5	− 6.4	80	12	62	30	27	41	36	48	44	78	2.74	− 0.8	14	4,671	ne.	30	sw.	21	7	5	19	6.9	0.4	....
Ludington	637	60	66	29.22	29.92	....	49.6	....	73	12	58	32	27	41	31	46	43	79	2.79	....	13	8,056	e.	37	sw.	7	6	12	13	6.4	T.	....
Marquette	734	77	111	29.18	29.99	+ .02	45.6	− 3.4	83	11	53	30	26	38	32	41	36	71	3.12	− 0.2	14	6,343	nw.	40	sw.	11	7	6	18	7.1	0.2	....
Port Huron	638	70	120	29.24	29.93	− .04	50.6	− 3.1	80	21	59	32	19	42	31	45	41	74	1.83	− 1.4	13	7,832	ne.	42	w.	7	5	14	12	6.1	T.	....
Saginaw	641	48	82	29.25	29.95	....	51.6	....	79	12	61	34	27	42	31	46	41	71	2.48	− 1.6	13	7,221	ne.	37	sw.	21	6	8	17	6.9	....	....
Sault Ste. Marie	614	11	61	29.26	29.96	+ .01	48.6	+ 0.9	74	31	58	30	27	39	35	43	37	66	1.69	− 1.6	8	6,385	w.	31	se.	7	6	10	15	6.4	T.	....
Chicago	823	140	310	29.02	29.92	− .04	54.1	− 2.4	86	12	60	41	17	48	27	49	45	75	7.04	+ 3.7	18	8,912	ne.	46	sw.	21	6	9	16	6.6	....	....
Green Bay	617	109	144	29.26	29.92	− .03	50.8	− 3.7	81	12	58	32	17	43	31	46	42	76	3.32	− 0.2	13	8,941	ne.	44	ne.	26	6	9	16	7.0	T.	....
Milwaukee	681	119	133	29.18	29.91	− .05	49.8	− 3.8	84	12	56	33	17	44	33	45	41	76	6.79	+ 3.4	17	9,023	ne.	46	sw.	21	5	10	16	6.6	T.	....
Duluth	1,133	11	47	28.74	29.97	+ .01	44.2	− 4.4	78	11	52	27	18	37	41	41	37	80	3.22	− 0.2	13	11,795	ne.	49	ne.	15	7	11	13	6.3	T.	....
North Dakota.							**51.4**	**− 2.8**										**65**	**3.11**	**+ 0.6**										**6.0**		
Moorhead	940	8	57	28.92	29.94	.00	51.7	− 3.1	80	31	62	29	18	41	40	47	42	74	3.93	+ 1.0	17	6,614	e.	40	se.	15	12	6	13	5.3	2.3	....
Bismarck	1,674	8	57	28.17	29.96	+ .04	51.0	− 4.2	83	10	62	24	18	40	38	44	38	67	4.43	+ 1.9	16	8,360	e.	48	e.	14	7	7	17	6.7	T.	....
Devils Lake	1,482	11	44	28.36	29.94	.00	50.7	− 2.0	79	31	63	22	6	39	41	43	36	62	2.13	− 0.1	9	9,360	e.	42	ne.	2	7	9	15	5.9	0.4	....
Williston	1,872	40	47	27.94	29.92	− .01	52.4	− 1.9	80	9	64	22	8	41	46	45	36	58	1.95	− 0.3	8	7,123	se.	36	nw.	7	6	12	13	6.3	....	....
Upper Mississippi Valley.							**57.9**	**− 4.0**										**74**	**6.68**	**+ 2.5**										**6.4**		
Minneapolis	918	10	208	28.90	29.88	....	52.2	....	86	11	61	27	18	44	30	....	....	....	3.98	+ 0.1	19	9,636	e.	48	ne.	17	5	5	21	7.7	2.0	....
St. Paul	837	201	236	28.97	29.88	− .06	52.2	− 6.0	86	11	61	29	18	44	31	....	....	....	3.88	+ 0.3	20	9,496	e.	62	se.	14	2	12	17	7.4	1.0	....
La Crosse	714	11	48	29.10	29.87	− .07	54.1	− 5.4	83	12	63	33	9	45	32	....	....	....	5.23	+ 1.5	17	3,726	e.	19	sw.	7	5	4	22	7.4	T.	....
Madison	974	70	78	28.87	29.92	− .04	51.8	− 5.8	80	12	59	35	18	44	28	47	43	74	5.98	+ 2.4	18	7,473	e.	36	sw.	21	4	4	23	8.0	....	....
Charles City	1,015	10	49	28.79	29.87	− .07	53.2	− 6.3	83	11	62	32	9	44	34	50	47	83	7.87	+ 2.9	18	5,609	e.	27	e.	26	8	11	12	6.3	....	....
Davenport	606	71	79	29.21	29.86	− .09	57.4	− 4.1	91	13	67	38	17	48	35	51	46	70	6.07	+ 1.9	15	7,516	e.	39	e.	26	10	9	12	5.6	....	....
Des Moines	861	84	97	28.93	29.83	− .10	57.3	− 4.3	92	13	67	34	9	48	33	52	47	72	8.21	+ 3.6	17	6,692	e.	30	sw.	11	7	8	16	6.5	....	....
Dubuque	698	81	96	29.15	29.90	− .05	54.8	− 6.0	82	12	63	37	18	46	32	49	44	72	7.61	+ 3.3	18	5,447	e.	24	sw.	21	4	7	20	7.5	....	....
Keokuk	614	64	78	29.19	29.85	− .09	60.1	− 3.1	94	13	70	40	17	50	32	54	50	74	5.79	+ 1.5	13	6,499	sw.	35	w.	16	11	11	9	4.8	....	....
Cairo	356	87	93	29.48	29.86	− .10	68.0	+ 0.5	92	14	77	48	5	59	31	61	57	73	4.13	+ 0.3	11	6,539	sw.	36	n.	25	8	9	14	6.1	....	....
Peoria	609	11	45	29.22	29.88	− .08	58.6	− 3.1	90	13	69	37	9	48	39	53	50	77	11.49	+ 7.2	18	5,511	w.	36	sw.	3	7	9	15	6.3	....	....
Springfield, Ill	644	10	91	29.19	29.87	− .08	60.5	− 3.0	92	13	70	41	19	51	36	54	49	71	9.86	+ 5.4	17	6,654	w.	34	se.	19	10	6	15	6.0	....	....
Hannibal	534	74	109	29.27	29.84	− .10	60.6	− 3.8	92	13	70	38	9	51	34	....	....	....	5.77	+ 0.8	14	7,322	sw.	36	sw.	3	13	4	14	5.5	....	....
St. Louis	567	265	303	29.26	29.86	− .09	64.6	− 1.9	91	13	73	47	5	56	30	57	52	70	7.67	+ 3.4	15	9,514	e.	47	w.	3	14	7	10	5.0	....	....
Missouri Valley.							**58.4**	**− 3.6**										**72**	**5.78**	**+ 1.5**										**5.8**		
Columbia, Mo	781	11	84	29.01	29.83	− .11	62.6	− 1.9	90	13	72	39	9	53	32	....	....	....	6.32	+ 1.5	10	6,104	sw.	32	nw.	25	10	9	12	5.9	....	....
Kansas City	963	161	181	28.81	29.84	− .08	62.4	− 2.1	90	13	71	39	18	54	27	55	49	67	11.00	+ 5.9	12	9,399	s.	48	ne.	26	10	11	10	5.2	....	....
St. Joseph	967	11	49	28.80	29.83	....	61.6	....	93	14	71	37	9	52	36	54	49	70	8.28	....	14	6,882	nw.	36	w.	3	12	10	9	5.3	....	....
Springfield, Mo	1,324	98	104	28.47	29.85	− .08	63.2	− 1.4	86	14	72	42	17	54	30	57	53	73	6.52	+ 1.0	14	7,248	se.	48	nw.	20	16	8	7	3.9	....	....
Iola	984	11	50	28.78	29.81	− .11	62.4	− 2.1	89	15	73	40	9	52	34	....	....	....	7.77	+ 2.7	12	5,208	sw.	26	nw.	23	13	7	11	4.7	....	....
Topeka	983	85	101	....	....	....	61.5	− 3.5	91	14	71	40	18	52	32	....	....	....	9.23	+ 4.4	13	7,853	s.	42	sw.	23	13	9	9	5.2	....	....
Lincoln	1,189	11	84	28.57	29.82	− .09	59.0	− 3.9	96	14	69	33	9	49	42	52	47	71	4.77	+ 0.5	14	9,124	s.	40	nw.	16	10	11	10	5.5	....	....
Omaha	1,105	115	121	28.66	29.84	− .08	58.9	− 3.6	96	14	68	36	18	49	31	53	49	73	6.05	+ 1.6	15	7,276	nw.	34	ne.	26	9	9	13	6.3	....	....
Valentine	2,598	47	54	27.16	29.87	− .03	52.7	− 5.2	93	12	64	27	6	42	41	47	42	75	3.84	+ 0.5	12	8,328	nw.	43	nw.	14	4	12	15	7.2	1.7	....
Sioux City	1,135	94	164	28.63	29.84	− .08	56.4	− 4.4	92	14	66	32	9	47	38	51	46	72	5.05	+ 0.7	17	10,557	e.	64	nw.	7	10	9	12	6.0	....	....
Huron	1,306	59	74	28.51	29.91	− .01	52.7	− 4.6	88	12	63	27	18	43	39	48	46	81	2.05	− 0.9	12	8,963	nw.	40	nw.	7	7	12	12	6.2	....	....
Pierre	1,572	70	75	28.25	29.92	+ .01	53.6	− 5.7	92	12	64	30	18	44	34	47	42	70	2.56	+ 0.4	16	8,418	e.	44	nw.	15	5	12	14	6.7	....	....
Yankton	1,233	49	57	28.53	29.84	− .08	55.7	− 4.3	91	12	65	32	18	46	37	....	....	....	4.14	+ 0.2	14	6,643	nw.	47	ne.	26	2	12	17	7.4	T.	....

TABLE I.—*Climatological data for United States Weather Bureau stations, May, 1915*—Continued.

Districts and stations.	Elevation of instruments. Barometer above sea level, feet.	Thermometer above ground.	Anemometer above ground.	Pressure in inches. Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Temperature of the air, in degrees Fahrenheit. Mean max.+mean min.÷2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.	Mean wet thermometer.	Mean temperature of the dew point.	Mean relative humidity, per cent.	Precipitation, inches. Total.	Departure from normal.	Days with 0.01 or more.	Wind. Total movement, miles.	Prevailing direction.	Maximum velocity. Miles per hour.	Direction.	Date.	Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow on ground at end of month.
Northern Slope.							**50.5**	**− 2.5**										**67**	**2.75**	**+ 0.4**										**6.6**		
Havre	2,505	11	44	27.26	29.88	−0.02	52.7	− 1.4	80	9	64	25	6	41	45	46	40	67	1.95	− 0.1	7	6,594	e.	42	sw.	9	10	13	8	5.6	T.	....
Helena	4,110	87	114	25.70	29.88	− .05	50.7	− 0.9	74	8	60	33	4	42	34	43	36	62	1.74	− 0.2	13	5,922	sw.	40	sw.	9	3	14	14	7.3	T.	....
Kalispell	2,962	11	34	26.83	29.87	− .01	51.4	+ 0.4	78	8	61	32	16	41	34	45	40	73	3.68	+ 1.6	17	2,835	nw.	32	sw.	9	4	10	17	7.1	....	....
Miles City	2,371	26	48	27.39	29.93	− .08	56.2	− 0.5	86	24	67	34	6	46	40	47	39	60	0.78	− 1.2	10	5,067	e.	40	w.	15	6	11	14	6.3	....	....
Rapid City	3,259	50	58	26.52	29.93	+ .03	50.2	− 4.0	80	24	59	28	18	42	34	45	40	70	3.41	+ 0.5	14	6,579	n.	36	n.	7	4	11	16	7.1	T.	....
Cheyenne	6,088	84	101	23.91	29.85	.00	46.4	− 4.4	79	13	57	21	18	36	35	39	33	66	2.21	− 0.2	13	8,988	nw.	52	w.	14	3	16	12	6.9	8.2	....
Lander	5,372	60	68	24.55	29.87	− .01	49.0	− 3.0	82	13	61	27	4	37	39	40	32	60	3.14	+ 0.2	15	4,232	sw.	34	n.	8	6	15	10	6.2	11.0	....
Sheridan	3,790	10	47	26.02	29.90	.....	50.5	.....	87	13	62	27	6	39	41	44	38	67	3.98	.....	17	6,117	nw.	48	se.	18	7	9	15	6.5	T.	....
Yellowstone Park	6,200	11	48	23.78	29.87	− .04	42.8	− 4.6	67	13	53	21	6	33	34	38	34	75	2.33	+ 0.4	19	5,720	s.	38	sw.	9	2	6	23	7.5	0.1	....
North Platte	2,821	11	51	26.97	29.88	.00	55.2	− 3.8	95	14	67	31	18	44	38	48	42	69	5.55	+ 2.5	10	6,006	ne.	37	nw.	14	15	3	13	5.2	4.9	....
Middle Slope.							**59.0**	**− 3.8**										**67**	**4.49**	**+ 0.6**										**5.1**		
Denver	5,291	129	172	24.62	29.85	+ .01	52.8	− 3.9	90	13	65	25	18	41	37	43	35	59	2.99	+ 0.4	10	6,674	sw.	50	nw.	14	7	12	12	6.0	6.4	....
Pueblo	4,685	80	86	25.17	29.82	− .01	55.6	− 3.9	92	13	68	27	7	43	42	43	33	51	1.75	+ 0.1	11	5,562	se.	46	w.	1	13	9	9	5.0	T.	....
Concordia	1,392	42	50	28.37	29.83	− .08	60.0	− 3.7	93	13	70	38	17	50	36	53	49	72	4.73	0.0	12	6,092	n.	29	nw.	3	7	15	9	5.6	....	....
Dodge	2,509	11	51	27.29	29.86	− .01	59.4	− 4.1	91	13	70	33	6	49	32	52	47	71	5.43	+ 2.1	9	8,266	s.	36	e.	18	14	7	10	4.8	0.7	....
Wichita	1,358	139	158	28.40	29.81	− .09	61.2	− 4.7	86	25	70	39	6	52	28	56	51	74	8.34	+ 3.4	11	10,213	s.	46	nw.	20	16	4	11	4.5	....	....
Oklahoma	1,214	10	47	28.58	29.84	− .05	65.3	− 2.8	88	15	75	42	7	56	28	59	55	74	3.69	− 2.1	10	9,436	s.	54	sw.	2	10	13	8	4.7	....	....
Southern Slope.							**68.2**	**− 2.4**										**57**	**1.54**	**− 1.2**										**3.6**		
Abilene	1,738	10	52	28.04	29.81	− .06	70.3	− 1.6	92	29	82	41	7	58	35	61	55	64	2.12	− 1.6	9	7,944	s.	40	nw.	29	12	11	8	4.5	....	....
Amarillo	3,676	10	49	26.14	29.81	− .05	61.5	− 2.8	92	25	75	30	7	48	41	52	46	64	1.70	− 2.0	9	9,263	s.	44	nw.	27	21	5	5	3.0	....	....
Del Rio	944	64	71	28.82	29.78	− .07	76.2	− 0.7	98	26	86	51	10	66	33	....	....	....	1.16	− 1.2	6	7,472	se.	39	sw.	29	12	14	5	4.4	....	....
Roswell	3,566	75	85	26.22	29.76	− .06	64.8	− 4.6	93	14	80	35	7	49	42	50	35	42	1.18	0.0	5	6,371	sw.	36	sw.	1	22	8	1	2.4	....	....
Southern Plateau.							**61.4**	**− 4.5**										**38**	**0.29**	**− 0.1**										**2.7**		
El Paso	3,762	110	133	26.04	29.72	− .06	69.6	− 2.5	95	13	83	45	3	56	38	49	26	24	T.	− 0.4	0	9,230	w.	45	w.	18	22	9	0	1.8	....	....
Santa Fe	7,013	57	62	23.16	29.76	− .05	52.3	− 4.4	79	13	63	28	3	41	30	41	29	46	0.83	− 0.3	10	6,706	sw.	34	se.	17	12	14	5	4.8	1.2	....
Flagstaff	6,908	8	57	.....	.....	.....	45.2	− 5.5	76	31	59	7	3	31	41	....	....	....	2.20	.....	7	.....	sw.	46	sw.	17	13	15	3	....	8.5	....
Phoenix	1,108	76	81	28.64	29.78	.00	70.8	− 4.0	102	12	85	42	2	57	38	53	38	37	0.17	+ 0.1	1	4,321	e.	25	se.	1	22	7	2	2.3	T.	....
Yuma	141	9	58	29.64	29.79	.00	72.6	− 4.2	104	28	89	39	2	56	44	57	45	43	T.	0.0	0	4,752	w.	30	w.	17	29	2	0	0.7	....	....
Independence	3,910	11	42	25.83	29.77	− .07	57.9	− 6.6	92	31	72	27	1	44	42	....	....	....	0.43	+ 0.3	3	5,543	se.	34	se.	12	14	15	2	3.7	1.5	....
Middle Plateau.							**54.0**	**− 2.5**										**53**	**1.02**	**− 0.2**										**5.8**		
Reno	4,532	74	81	25.36	29.86	− .05	52.1	− 1.5	83	27	64	27	2	41	41	41	32	54	0.52	− 0.3	7	6,481	w.	33	w.	17	9	12	10	5.7	1.7	....
Tonopah	6,090	12	20	23.95	29.81	.....	50.3	.....	81	31	61	18	1	40	29	40	31	54	0.35	− 1.0	5	7,666	se.	43	nw.	19	8	16	7	5.4	3.9	....
Winnemucca	4,344	18	56	25.50	29.86	− .05	52.3	− 2.1	82	30	66	24	2	39	41	42	34	61	1.08	0.0	11	4,498	sw.	34	nw.	31	9	10	12	5.9	5.2	....
Modena	5,479	10	43	24.49	29.80	− .02	50.8	− 3.7	81	31	64	25	1	38	39	40	30	54	0.97	+ 0.1	9	8,639	sw.	59	sw.	17	6	13	12	6.0	2.8	....
Salt Lake City	4,360	147	189	25.47	29.80	− .06	56.7	− 1.6	83	31	67	33	3	47	33	46	36	50	1.97	0.0	13	5,892	nw.	34	se.	17	5	11	15	6.3	T.	....
Grand Junction	4,602	82	96	25.24	29.77	− .06	58.1	− 3.5	88	13	70	29	2	46	34	45	32	44	1.23	+ 0.3	10	5,919	se.	47	w.	14	9	12	10	5.6	T.	....
Northern Plateau.							**54.8**	**− 2.1**										**63**	**3.24**	**+ 1.5**										**7.0**		
Baker	3,471	48	53	26.35	29.92	− .04	49.8	− 0.9	75	7	60	28	2	40	37	43	37	68	3.18	+ 1.4	18	4,273	se.	23	w.	10	4	17	10	6.6	T.	....
Boise	2,739	78	86	27.05	29.90	− .04	55.0	− 2.6	79	30	64	33	1	46	35	47	40	62	4.26	+ 3.0	16	4,134	nw.	28	nw.	31	5	6	20	7.3	T.	....
Lewiston	757	40	48	29.07	29.88	− .08	58.7	− 2.1	86	8	69	39	4	48	36	....	....	....	2.85	+ 1.2	19	2,126	e.	22	nw.	10	3	13	15	7.1	....	....
Pocatello	4,477	46	54	25.35	29.84	− .05	51.6	− 3.9	77	31	62	28	5	41	34	43	36	62	3.31	+ 1.1	18	4,949	se.	34	sw.	28	4	10	17	7.1	T.	....
Spokane	1,929	101	110	27.85	29.89	− .05	55.6	− 0.5	79	8	65	35	1	46	32	48	41	62	3.36	+ 1.7	15	4,574	s.	26	sw.	10	2	9	20	7.2	T.	....
Walla Walla	1,000	57	65	28.81	29.88	− .08	58.0	− 2.7	83	7	68	35	2	48	33	50	43	63	2.48	+ 0.6	19	3,355	s.	26	sw.	16	5	12	14	6.6	....	....
North Pacific Coast Region.							**54.3**	**+ 1.2**										**78**	**3.20**	**+ 0.6**										**6.9**		
North Head	211	11	56	29.72	29.95	− .08	52.5	+ 1.3	70	4	56	43	1	49	17	50	49	90	3.93	+ 1.5	21	12,217	se.	56	se.	24	4	9	18	7.2	....	....
Port Crescent	259	8	53	29.66	29.94	− .08	50.4	+ 1.3	73	4	58	35	16	43	35	....	....	....	2.70	+ 0.4	17	3,428	s.	18	n.	28	3	13	15	7.1	....	....
Seattle	125	215	250	29.81	29.94	− .07	56.0	+ 1.0	78	5	63	44	1	48	27	51	48	78	1.72	− 0.6	12	6,315	s.	34	sw.	14	3	9	19	7.3	....	....
Tacoma	213	113	120	29.71	29.94	− .08	55.4	+ 0.9	79	6	64	41	2	47	29	50	44	71	3.01	+ 0.5	20	4,235	sw.	26	sw.	9	4	15	12	6.5	....	....
Tatoosh Island	109	7	57	29.81	29.91	− .10	51.9	+ 2.3	65	16	56	43	1	48	19	49	47	85	5.08	+ 1.0	23	8,971	s.	42	e.	16	5	4	22	7.4	....	....
Portland, Oreg.	153	68	106	29.77	29.92	− .11	57.7	+ 0.9	81	5	66	36	1	49	30	51	46	70	2.59	+ 0.2	19	4,452	sw.	22	sw.	21	8	5	18	6.6	....	....
Roseburg	510	9	57	29.40	29.95	− .08	56.4	+ 0.4	78	5	66	33	1	46	37	50	45	72	3.36	+ 1.3	22	2,305	s.	17	w.	21	2	20	9	6.3	....	....
Middle Pacific Coast Region.							**56.1**	**− 1.4**										**75**	**2.95**	**+ 1.6**										**5.9**		
Eureka	62	73	89	29.94	30.01	− .04	53.6	+ 1.5	66	9	58	42	3	49	15	50	48	85	2.07	− 0.5	19	5,627	sw.	36	n.	1	3	13	15	7.2	....	....
Mount Tamalpais	2,375	11	18	27.49	29.97	− .03	49.3	− 4.4	80	27	55	34	1	44	19	45	42	81	5.08	+ 3.6	15	16,153	nw.	78	nw.	18	8	11	12	6.2	T.	....
Point Reyes Light	490	7	18	29.42	29.94	.....	52.6	+ 1.0	60	27	56	43	1	49	9	....	....	....	2.82	.....	13	19,362	nw.	70	nw.	28	8	9	14	6.3	....	....
Red Bluff	332	50	56	29.56	29.92	− .03	62.0	− 4.5	90	29	71	43	2	53	33	53	47	66	1.92	+ 0.6	11	4,361	se.	27	se.	10	8	11	12	6.1	....	....
Sacramento	69	106	117	29.86	29.93	− .01	59.8	− 3.1	89	27	69	42	2	51	30	53	48	69	2.75	+ 1.8	10	6,160	s.	26	s.	17	13	9	9	4.9	....	....
San Francisco	155	209	213	29.80	29.97	− .02	57.6	+ 2.1	81	27	63	46	2	52	27	52	48	75	3.17	+ 2.4	11	6,913	sw.	29	sw.	31	12	6	13	5.2	....	....
San Jose	141	12	110	29.84	29.91	.....	58.1	− 2.6	88	27	67	41	2	49	36	....	....	....	2.69	+ 2.0	10	5,005	nw.	26	se.	3	11	7	13	5.7	....	....
South Pacific Coast Region.							**60.7**	**− 0.9**										**73**	**1.02**	**+ 0.4**										**4.9**		
Fresno	327	89	98	29.58	29.93	+ .01	63.0	− 5.4	93	27	75	40	2	51	36	53	46	62	0.99	+ 0.4	7	6,569	nw.	31	nw.	19	9	13	9	5.0	....	....
Los Angeles	338	159	191	29.56	29.93	− .02	61.5	+ 1.0	95	27	70	41	1	53	31	55	50	74	0.88	+ 0.4	4	4,732	sw.	28	nw.	19	10	15	6	4.8	....	....
San Diego	87	62	70	29.84	29.93	− .02	60.6	− 0.2	84	27	66	45	3	55	24	55	52	78	0.28	− 0.1	6	5,677	w.	27	sw.	1	10	19	2	4.4	....	....
San Luis Obispo	201	32	40	29.78	30.00	.00	57.8	+ 1.1	90	27	68	35	1	48	33	51	48	78	1.91	+ 1.0	9	3,805	w.	24	w.	19	10	8	13	5.4	....	....
West Indies.																																
San Juan	82	8	54	29.88	29.97	− .02	78.8	.....	88	17	84	69	3	74	14	....	....	....	4.62	− 0.1	14	9,280	e.	31	e.	18	13	11	7	4.7	....	....
Panama.																																
Balboa Heights	116	7	97	29.68	29.80	.....	81.2	.....	93	3	87	72	26	75	19	77	76	89	6.42	− 2.2	19	5,096	n.	47	sw.	26	0	17	14	6.9	....	....
Colon	25	5	71	29.78	29.81	.....	82.0	.....	89	6	86	74	27	78	13	78	77	88	7.75	− 4.9	20	6,404	se.	23	sw.	15	3	14	14	7.3	....	....

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes for the principal storms in which the rate of fall equaled or exceeded 0.25 inch in any 5 minutes, or 0.80 in 1 hour, during May, 1915, at all stations furnished with self-registering gages.*

Stations.	Date.	Total duration.		Total amount of precipitation.	Excessive rate.		Amount before excessive rate began.	Depths of precipitation (in inches) during periods of time indicated.													
		From—	To—		Began—	Ended—		5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Abilene, Tex.	29	8:50 p.m.	D.N. p.m.	1.37	8:52 p.m.	9:23 p.m.	0.01	0.08	0.24	0.55	0.85	1.12	1.23	1.26							
Albany, N. Y.	21			0.38														0.22			
Alpena, Mich.	12			1.29														.44			
Amarillo, Tex.	16	2:37 p.m.	3:05 p.m.	0.39	2:46 p.m.	3:03 p.m.	.01	.17	.28	.35	.38										
Anniston, Ala.	6–7	11:00 p.m.	3:30 p.m.	3.10	6:39 a.m.	7:05 a.m.	.44	.07	.22	.73	1.19	1.43	1.48								
Asheville, N. C.	7			1.18														.34			
Atlanta, Ga.	7	6:05 a.m.	5:25 p.m.	3.69	7:09 a.m.	7:51 a.m.	.04	.27	.51	.62	.78	.98	1.18	1.39	1.59	1.62					
					8.44 a.m.	9:07 a.m.	1.85	.18	.34	.43	.63	.73									
Atlantic City, N. J.	22			0.89														.43			
Augusta, Ga.	23-24	11:00 p.m.	D.N.a.m.	3.66	11:07 p.m.		.24	.51	.70	.90	1.14	1.32	1.58	1.79	1.89	1.97					
							2.00	2.08	2.22	2.33	2.34	2.34	2.35	2.35	2.54	2.58					
						1:24 a.m.	2.64	2.93	3.00	3.05	3.20	3.31	3.36	3.41							
Baker, Oreg.	28			0.44														.23			
Baltimore, Md.	22			0.93														.33			
Bentonville, Ark.	19	2:10 p.m.	5:35 p.m.	1.80	3:20 p.m.	5:20 p.m.	.19	.10	.16	.22	.39	.60	.62	.63	.66	.79	.85	.92	1.03	1.33	1.61
	20	5:23 p.m.	9:22 p.m.	1.36	5:46 p.m.	6:21 p.m.	.01	.17	.48	.66	.79	.93	1.10	1.17							
	26–27	7:50 p.m.	12:45 a.m.	1.85	8:07 a.m.	8:27 p.m.	T.	.38	.72	.87	.95										
	27	5:25 p.m.	10:15 p.m.	0.97	8:28 p.m.	8:40 p.m.	.34	.33	.55	.62											
Binghamton, N. Y.	20–21			0.72														.36			
Birmingham, Ala.	6–7	8:20 p.m.	1:47 p.m.	3.76	5:29 a.m.	6:30 a.m.	.67	.37	.95	1.24	1.32	1.48	1.51	1.61	1.67	1.71	1.79	2.01	2.09		
Bismarck, N. Dak.	14–15	7:30 p.m.	6:35 a.m.	1.36	10:14 p.m.	10:36 p.m.	.34	.07	.22	.40	.54	.58									
Block Island, R. I.	21–22			1.39														(*)			
Boise, Idaho.	12–14			1.51														.33			
Boston, Mass.	21–22			0.49														.26			
Buffalo, N. Y.	7			0.57														.15			
Burlington, Vt.	26			0.66														(*)			
Cairo, Ill.	23	8:05 a.m.	10:40 a.m.	1.24	9:43 a.m.	10:03 a.m.	.46	.12	.34	.61	.68										
Canton, N. Y.	21			0.28														.28			
Charles City, Iowa.	2			1.83														.41			
Charleston, S. C.	7	6:40 p.m.	D.N. p.m.	0.95	7:10 p.m.	7:46 p.m.	.22	.11	.12	.14	.24	.34	.42	.56	.61						
	8	D.N. a.m.	6:15 a.m.	0.80	3:30 a.m.	3:43 a.m.	.02	.31	.56	.63											
	12	7:42 a.m.	1:20 p.m.	4.08	7:48 a.m.	8:38 a.m.	.01	.17	.37	.51	.59	.71	.82	.96	1.18	1.44	1.67				
					10:28 a.m.	11:01 a.m.	2.53	.12	.32	.44	.59	.81	.94	.98							
Charlotte, N. C.	7	6:43 a.m.	8:15 p.m.	2.58	2:31 p.m.	2:42 p.m.	1.58	.48	.86	.90											
Chattanooga, Tenn.	6–7			2.36														.35			
Cheyenne, Wyo.	17–18			1.17														(*)			
Chicago, Ill.	15	5:19 p.m.	9:40 p.m.	1.41	6:07 p.m.	6:30 p.m.	.07	.08	.25	.31	.40	.48									
Cincinnati, Ohio.	26	1:53 a.m.	6:40 a.m.	1.58	3:26 a.m.	4:12 a.m.	.11	.09	.19	.36	.55	.62	.75	.85	1.06	1.22	1.24				
Cleveland, Ohio.	21	D.N. a.m.	7:26 a.m.	0.60	6:18 a.m.	6:50 a.m.	.05	.13	.19	.28	.32	.44	.52	.55							
Columbia, Mo.	26–27			2.60														.67			
Columbia, S. C.	7	11:50 a.m.	12:50 p.m.	0.53	12:20 p.m.	12:33 p.m.	.05	.11	.25	.43											
		2:30 p.m.	3:12 p.m.	0.43	2:33 p.m.	2:47 p.m.	.01	.15	.27	.35											
Columbus, Ohio.	20			0.73														(*)			
Concord, N. H.	13			0.28														.27			
Concordia, Kans.	26			0.93														.40			
Corpus Christi, Tex.	31	6:24 a.m.	9:35 a.m.	1.98	6:38 a.m.	7:03 a.m.	.06	.14	.49	.85	1.33	1.53									
Davenport, Iowa.	25	7:25 a.m.	10:25 a.m.	0.93	8:08 a.m.	8:20 a.m.	.04	.29	.60	.67											
Dayton, Ohio.	29–30			1.24														57			
Del Rio, Tex.	31	1:00 a.m.	2:10 a.m.	0.68	1:03 a.m.	1:33 a.m.	.01	.08	.20	.39	.51	.57	.64								
Denver, Colo.	18–20			1.03														(*)			
Des Moines, Iowa.	2	7:20 p.m.	8:15 p.m.	0.53	7:42 p.m.	8:01 p.m.	.02	.08	.30	.44	.51										
	27–28	5:50 p.m.	2:20 p.m.	3.03	6:45 p.m.	7:07 p.m.	.29	.14	.18	.29	.53	.58									
					8:08 p.m.	10:08 p.m.	.99	.05	.10	.15	.27	.38	.52	.68	.76	.84	.97	1.12	1.30	1.53	1.74
Detroit, Mich.	15–16			1.10														.40			
Devils Lake, N. Dak.	14–15			1.52														(*)			
Dodge City, Kans.	18			2.44														.55			
Dubuque, Iowa.	27–29			2.30														(*)			
Duluth, Minn.	15–16			1.54														.22			
Eastport, Me.	8			0.61														.13			
Elkins, W. Va.	12			0.58														.17			
El Paso, Tex.	31			T.														T.			
Erie, Pa.	21	1:27 p.m.	3:35 p.m.	0.44	2:43 p.m.	2:52 p.m.	.01	.24	.39												
Escanaba, Mich.	6–7			0.92														.12			
Eureka, Cal.	17			0.24														.09			
Evansville, Ind.	23	7:08 a.m.	2:45 p.m.	2.07	7:37 a.m.	8:00 a.m.	.02	.19	.47	.64	.79	.85									
					1:06 p.m.	2:00 p.m.	1.22	.05	.13	.33	.47	.48	.49	.55	.59	.62	.64	.83			
	25	2:43 p.m.	5:00 p.m.	0.64	2:48 p.m.	3:18 p.m.	.01	.11	.33	.42	.47	.52	.56								
Flagstaff, Ariz.	17–18			0.68														(*)			
Fort Smith, Ark.	21–22	8:58 p.m.	D. N. a.m.	1.68	10:06 p.m.	10:38 p.m.	.04	.33	.52	.76	1.06	1.27	1.35								
	26	2:35 p.m.	6:16 p.m.	1.05	4:02 p.m.	4:44 p.m.	.11	.06	.10	.15	.22	.40	.47	.57	.75	.84					
	26–27	7:36 p.m.	D. N. a.m.	1.04	7:42 p.m.	8:02 p.m.	.01	.11	.32	.47	.55										
Fort Wayne, Ind.	24	D. N. a.m.	D. N. a.m.	0.74	1:44 a.m.	2:28 a.m.	.02	.18	.25	.30	.34	.39	.48	.54	.63	.67					
Fort Worth, Tex.	19			0.75														.70			
Fresno, Cal.	17			0.44														.13			
Galveston, Tex.	31	5:55 p.m.	7:20 p.m.	0.63	6:10 p.m.	6:33 p.m.	.05	.16	.38	.45	.54	.58									
Grand Haven, Mich.	15			0.54														.21			
Grand Junction, Colo.	18–20			0.85														.17			
Grand Rapids, Mich.	25			0.63														.21			
Green Bay, Wis.	20			0.55														.27			
Hannibal, Mo.	2	10:33 a.m.	11:55 a.m.	0.63	10:53 a.m.	11:09 a.m.	.01	.26	.43	.52	.54										
	25	9:10 a.m.	12:35 p.m.	0.91	9:18 a.m.	9:42 a.m.	.02	.08	.28	.43	.51	.57									
Harrisburg, Pa.	21	8:30 p.m.	10:10 p.m.	0.94	9:05 p.m.	9:30 p.m.	.08	.13	.28	.36	.71	.79									
Hartford, Conn.	21–22			1.09														.67			
Hatteras, N. C.	24–25	9:57 p.m.	D. N. a.m.	1.58	10:11 p.m.	10:37 p.m.	.05	.10	.24	.38	.48	.57	.60								
					11:31 p.m.	11:51 p.m.	.80	.17	.36	.68	.73										
	27	12:17 a.m.	D. N. a.m.	0.92	12:20 a.m.	12:34 a.m.	.01	.29	.68	.78											
Havre, Mont.	13–14			0.95														.24			
Helena, Mont.	14			0.28														.20			
Houghton, Mich.	11	2:40 a.m.	5:30 a.m.	0.72	2:48 a.m.	2:59 a.m.	.02	.23	.51	.56											
Houston, Tex.	27			0.53														.45			
Huron, S. Dak.	2			0.96														.43			
Independence, Cal.	5			0.19														.09			
Indianapolis, Ind.	6–7			0.81														(*)			
Iola, Kans.	18–19	9:03 p.m.	4:28 p.m.	2.49	9:36 a.m.	10:16 a.m.	1.62	.13	.18	.21	.26	.36	.42	.51	.60						
	26	12:01 p.m.	1:33 p.m.	1.14	12:42 p.m.	1:07 p.m.	.01	.19	.49	.74	.97	1.10									
Jacksonville, Fla.	13	4:50 p.m.	6:20 p.m.	0.40	5:41 p.m.	5:48 p.m.	.01	.25	.33												
Kalispell, Mont.	21			0.66														.28			

(*) Self-register not working.

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes for the principal storms in which the rate of fall equaled or exceeded 0.25 inch in any 5 minutes, or 0.80 in 1 hour, during May, 1915, at all stations furnished with self-registering gages*—Continued.

Stations.	Date.	Total duration. From—	Total duration. To—	Total amount of precipitation.	Excessive rate. Began—	Excessive rate. Ended—	Amount before excessive rate began.	5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Kansas City, Mo.	27	12:55 p.m.	9:00 p.m.	1.75	3:10 p.m.	3:30 p.m.	.63	.11	.19	.46	.63										
Keokuk, Iowa	25-26	6:30 p.m.	6:50 a.m.	1.88	10:36 a.m.	10:46 a.m.	.53	.28	.47												
Key West, Fla.	12	9:20 p.m.	10:30 p.m.	0.79	9:45 p.m.	10:04 p.m.	.05	.23	.34	.63	.70										
	23	12:42 p.m.	1:20 p.m.	0.71	12:51 p.m.	1:08 p.m.	.02	.25	.48	.65	.69										
Knoxville, Tenn.	7			1.04														(*)			
La Crosse, Wis.	2			0.82														.44			
Lander, Wyo.	25			0.46														.14			
Lansing, Mich.	16			0.50														.20			
Lewiston, Idaho	21			0.26														.26			
Lexington, Ky.	6-7	7:05 p.m.	D. N. a.m.	1.79	12:58 a.m.	1:16 a.m.	.46	.32	.39	.44	.48										
Lincoln, Nebr.	26-27			1.43														(*)			
Little Rock, Ark.	5-6	10:25 p.m.	D. N. a.m.	1.02	2:44 a.m.	3:11 a.m.	.12	.20	.44	.51	.61	.69	.76								
Los Angeles, Cal.	1-2			0.57														(*)			
Louisville, Ky.	20			0.89														.36			
Ludington, Mich.	15-16			0.69														.22			
Lynchburg, Va.	23	6:30 p.m.	7:20 p.m.	0.40	6:51 p.m.	7:02 p.m.	.01	.24	.36	.38											
Macon, Ga.	12	11:35 a.m.	12:25 p.m.	0.56	11:55 a.m.	12:19 p.m.	.02	.05	.13	.29	.36	.54									
Madison, Wis.	2-3	9:50 p.m.	D. N. a.m.	1.07	12:56 a.m.	1:25 a.m.	.57	.10	.26	.33	.41	.46	.50								
	14-15	9:05 p.m.	D. N. a.m.	0.94	10:33 p.m.	11:13 p.m.	.08	.17	.31	.42	.47	.51	.53	.55	.66						
Marquette, Mich.	11-12			0.90														.20			
Memphis, Tenn.	6	2:50 a.m.	5:10 a.m.	0.64	3:26 a.m.	3:38 a.m.	.05	.22	.52	.56											
	6	12:19 p.m.	D. N. p.m.	1.70	6:46 p.m.	7:11 p.m.	.93	.09	.15	.26	.44	.60									
	21	5:06 a.m.	6:20 a.m.	0.79	5:34 a.m.	6:02 a.m.	.02	.20	.36	.52	.59	.70	.74								
Meridian, Miss.	6	4:25 p.m.	7:45 p.m.	1.19	4:50 p.m.	5:19 p.m.	.10	.12	.18	.18	.23	.46	.50								
	7	6:03 a.m.	8:35 a.m.	0.95	6:58 a.m.	7:30 a.m.	.01	.12	.31	.44	.54	.67	.79	.84							
Miami, Fla.	18	8:38 a.m.	11:50 a.m.	0.80	8:40 a.m.	8:59 a.m.	.01	.23	.43	.62	.67										
	29	4:50 p.m.	D. N. p.m.	1.38	6:12 p.m.	6:24 p.m.	.13	.13	.31	.39											
					8:11 p.m.	8:37 p.m.	.69	.28	.41	.49	.63	.65	.69								
Milwaukee, Wis.	28			1.62														(*)			
Minneapolis, Minn.	2-3			0.58														.39			
Mobile, Ala.	7	11:15 a.m.	1:55 p.m.	0.78	11:42 a.m.	12:22 p.m.	.10	.07	.12	.27	.36	.45	.49	.56	.63						
Modena, Utah	5			0.29														.08			
Montgomery, Ala.	7	9:20 a.m.	2:05 p.m.	2.03	11:36 a.m.	12:27 p.m.	.14	.08	.34	.60	.85	1.02	1.26	1.36	1.41	1.58	1.72				
	26	5:25 p.m.	7:40 p.m.	1.37	6:30 p.m.	7:10 p.m.	.27	.10	.49	.62	.77	.83	.99	1.07							
Moorhead, Minn.	2-4			1.54														.32			
Mount Tamalpais, Cal.	8-12			2.63														.26			
Nantucket, Mass.	12-13			1.24														.45			
Nashville, Tenn.	22	5:40 a.m.	8:30 a.m.	0.93	5:40 a.m.	5:49 a.m.	.00	.42	.50												
	23	4:10 p.m.	8:20 p.m.	0.78	5:00 p.m.	5:22 p.m.	.01	.13	.19	.26	.49	.52									
	27	3:45 p.m.	3:45 p.m.	0.38	6:15 p.m.	6:45 p.m.	.16	.20	.27	.30	.40	.46	.54								
New Haven, Conn.	21-22	7:15 a.m.	D. N. a.m.	1.10	10:47 p.m.	11:18 p.m.	.20	.14	.19	.22	.36	.43	.52	.54							
New Orleans, La.	28	4:15 a.m.	7:10 a.m.	1.25	4:45 a.m.	5:45 a.m.	.06	.07	.31	.57	.70	.76	.79	.80	.85	.86	.90	1.08			
New York, N. Y.	21-22			1.19														.46			
Norfolk, Va.	7	2:47 p.m.	3:48 p.m.	0.95	3:11 p.m.	3:41 p.m.	.01	.25	.34	.45	.65	.85	.94								
	12	7:20 a.m.	7:10 p.m.	1.68	3:27 p.m.	3:47 p.m.	.39	.12	.31	.47	.70										
Northfield, Vt.	8			0.32														.22			
North Head, Wash.	21-22			0.60														.20			
North Platte, Nebr.	26-27			2.66														(*)			
Oklahoma, Okla.	22	6:50 p.m.	7:15 p.m.	0.36	6:53 p.m.	6:58 p.m.	.01	.26													
Omaha, Nebr.	25	1:45 a.m.	6:15 a.m.	1.64	3:32 a.m.	4:15 a.m.	.62	.05	.18	.36	.52	.61	.67	.75	.83	.86					
Oswego, N. Y.	21			0.25														.21			
Palestine, Tex.	27			0.73														.61			
Parkersburg, W. Va.	20-21			1.34														(*)			
Pensacola, Fla.	7-8	11:50 a.m.	12:35 a.m.	5.47	2:04 p.m.	2:52 p.m.	.12	.14	.27	.44	.61	.79	.83	1.02	1.29	1.40	1.46				
					7:35 p.m.	8:19 p.m.	2.12	.07	.21	.73	1.22	1.50	1.86	2.03	2.16	2.30					
	11	4:00 a.m.	9:05 p.m.	1.62	7:21 a.m.	7:51 a.m.	.34	.38	.66	.78	.82	.95	1.03								
	30-31	7:10 p.m.	12:45 a.m.	1.08	8:41 p.m.	9:02 p.m.	.05	.09	.26	.50	.72	.74									
Peoria, Ill.	13	7:16 p.m.	8:25 p.m.	1.15	7:25 p.m.	8:04 p.m.	.01	.12	.30	.66	.94	.99	1.03	1.09	1.13						
	20-21	7:05 p.m.	D.N. a.m.	1.92	10:40 p.m.	11:21 p.m.	.45	.21	.54	.63	.69	.77	.92	1.08	1.24	1.26					
	25	9:53 a.m.	11:55 a.m.	0.87	9:53 a.m.	10:09 a.m.	.00	.24	.53	.73	.74										
	28	4:10 p.m.	D.N. p.m.	4.47	6:36 p.m.	8:21 p.m.	.64	.09	.21	.34	.52	.68	.83	.94	1.05	1.14	1.17	1.28	1.65	1.92	2.23
Philadelphia, Pa.	20-22			1.49														.34			
Phoenix, Ariz.	1			0.17														.15			
Pierre, S. Dak.	26-27			1.14														(*)			
Pittsburgh, Pa.	29-30			1.46														.35			
Pocatello, Idaho	19	5:36 p.m.	9:45 p.m.	0.73	5:45 p.m.	6:75 p.m.	0.04	.13	.22	.26	.37	.50	.64								
Point Reyes Light, Cal.	8-11			1.72														.19			
Port Huron, Mich.	3			0.40														.14			
Portland, Me.	8			0.88														.35			
Portland, Oreg.	9-10			0.49														(*)			
Providence, R. I.	21-22			0.79														.46			
Pueblo, Colo.	5-6			0.85														(*)			
Raleigh, N. C.	7	11:23 a.m.	11:46 a.m.	0.59	11:28 a.m.	11:41 a.m.	.01	.12	.33	.58											
Rapid City, S. Dak.	25-27			1.24														(*)			
Reading, Pa.	20-22			1.11														.50			
Red Bluff, Cal.	11-13			0.76														.17			
Reno, Nev.	3-4			0.33														.07			
Richmond, Va.	12	8:15 a.m.	12:16 p.m.	1.15	10:50 a.m.	11:17 a.m.	.50	.08	.34	.45	.54	.59	.63								
Rochester, N. Y.	21	4:35 p.m.	5:25 p.m.	0.41	4:41 p.m.	4:48 p.m.	.01	.29	.34												
Roseburg, Oreg.	12			0.20														.16			
Roswell, N. Mex.	23			0.93														.70			
Sacramento, Cal.	11-12			1.33														.39			
Saginaw, Mich.	3-4			0.87														.40			
St. Joseph, Mo.	23	7:50 a.m.	9:45 a.m.	0.83	8:10 a.m.	8:37 a.m.	.01	.08	.17	.32	.50	.58	.62								
St. Louis, Mo.	19-20	5:10 p.m.	D.N. a.m.	2.15	9:51 p.m.	10:26 p.m.	.91	.08	.22	.43	.58	.67	.77	.84							
St. Paul, Minn.	2-3			0.54														.34			
Salt Lake City, Utah	17-18			0.79														.15			
San Antonio, Tex.	30	12:45 a.m.	2:00 a.m.	0.72	12:52 a.m.	1:09 a.m.	.05	.14	.39	.62	.66										
San Diego, Cal.	4			0.10														.06			
Sand Key, Fla.	12	8:46 p.m.	10:10 p.m.	0.99	9:21 p.m.	9:46 p.m.	.01	.08	.38	.70	.86	.95									
Sandusky, Ohio	15-16			0.82														.32			
San Francisco, Cal.	11			1.05														.29			
San Jose, Cal.	3-5			1.56														.16			
San Luis Obispo, Cal.	4			1.02														.36			
Santa Fe, N. Mex.	6			0.30														(*)			
Sault Ste. Marie, Mich.	7			0.82														.24			

(*) Self-register not working.

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes for the principal storms in which the rate of fall equaled or exceeded 0.25 inch in any 5 minutes, or 0.80 in 1 hour, during May, 1915, at all stations furnished with self-registering gages*—Continued.

Stations.	Date.	Total duration. From—	Total duration. To—	Total amount of precipitation.	Excessive rate. Began—	Excessive rate. Ended—	Amount before excessive rate began.	5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Savannah, Ga	8	D. N. a.m.	1:10 p.m.	1.32	2:36 a.m.	2:55 a.m.	.02	.31	.51	.62	.69										
	11	10:30 a.m.	8:35 p.m.	4.60	1:48 p.m.	2:28 p.m.	1.38	.43	.77	.92	1.08	1.20	1.26	1.36	1.42						
	26	5:22 p.m.	7:40 p.m.	0.91	5:27 p.m.	5:41 p.m.	.01	.20	.55	.69											
	31	5:15 p.m.	7:10 p.m.	0.70	6:42 p.m.	6:57 p.m.	.01	.13	.43	.69											
Scranton, Pa	21	7:25 p.m.	9:30 p.m.	1.01	8:04 p.m.	8:38 p.m.	.05	.11	.17	.23	.36	.52	.72	.78							
Seattle, Wash	26–28			0.88														(*)			
Sheridan, Wyo	[1]30–3			2.71														.19			
Shreveport, La	27	6:00 a.m.	8:00 a.m.	1.44	6:58 a.m.	7:29 a.m.	.06	.11	.37	.70	1.02	1.18	1.33	1.36							
Sioux City, Iowa	25–26	9:50 p.m.	12:20 a.m.	1.13	11:12 p.m.	11:37 p.m.	.25	.07	.23	.40	.73	.83									
Spokane, Wash	17–19			1.91														.19			
Springfield, Ill	25–26	10:38 p.m.	D. N. a.m.	2.40	11:00 p.m.	12:59 a.m.	.14	.08	.13	.20	.34	.40	.40	.43	.46	.51	.70	1.00	1.37	1.81	2.13
	26	D. n. a.m.	9:40 a.m.	2.34	4:34 a.m.	4:58 a.m.	.05	.20	.37	.49	.74	.87									
					5:48 a.m.	6:39 a.m.	.95	.10	.27	.37	.46	.55	.63	.89	1.04	1.11	1.17	1.24			
Springfield, Mo	19	11:55 a.m.	6:10 p.m.	1.36	5:33 p.m.	6:01 p.m.	.72	.06	.14	.24	.39	.58	.63								
	20	10:47 a.m.	12:12 p.m.	1.01	10:46 a.m.	11:14 a.m.	.01	.08	.12	.24	.32	.50	.55								
Syracuse, N. Y	13			0.51														.51			
Tacoma, Wash	26–27			1.09														(*)			
Tampa, Fla	9	5:00 a.m.	5:50 p.m.	2.39	9:20 a.m.	9:38 a.m.	.31	.21	.61	1.00	1.19										
	13	4:30 a.m.	5:50 a m.	0.81	5:05 a.m.	5:29 a.m.	.01	.15	.19	.38	.59	.78									
	31	9:17 a.m.	11:20 a.m.	1.86	9:41 a.m.	10:41 a.m.	.05	.17	.33	.64	.88	1.07	1.18	1.30	1.40	1.47	1.60	1.70			
Tatoosh Island, Wash	9–11			2.12														.27			
Taylor, Tex	30	D. N. a.m.	D. N. a.m	0.89	2:51 a.m.	3:12 a.m.	.01	.08	.29	.45	.56	.59									
Terre Haute, Ind	25	1:22 p.m.	3:20 p.m.	0.97	1:25 p.m.	1:38 p.m.	.01	.52	.72	.77											
Thomasville, Ga	29	5:22 a.m.	7:36 a.m.	1.03	5:49 a.m.	5:59 a.m.	.07	.21	.49												
Toledo, Ohio	23–24			1.57														.47			
Tonopah, Nev	2			0.15														(*)			
Topeka, Kans	23	6:50 a.m.	9:10 a.m.	0.81	7:13 a.m.	7:19 a.m.	.01	.39	.51												
	26	7:25 a.m.	11:10 a.m.	1.44	9:37 a.m.	10:33 a.m.	.10	.19	.22	.23	.25	.31	.39	.46	.68	.97	1.14	1.29			
	27	1:38 p.m.	6:15 p.m.	1.16	2:24 p.m.	2:32 p.m.	.10	.41	.64												
Valentine, Nebr	26–28			1.41														(*)			
Vicksburg, Miss	27	10:46 a.m.	4:08 p.m.	1.82	11:12 a.m.	11:49 a.m.	.04	.16	.29	.34	.52	.64	.72	.85	.91						
Walla Walla, Wash	17–19			0.66														(*)			
Washington, D. C	22			0.70														(*)			
Wichita, Kans	18–19	7:35 p.m.	7:15 a.m.	3.79	9:26 p.m.	10:14 p.m.	0.56	.12	.18	.26	.37	.43	.53	.59	.66	.71	.75				
					11:26 p.m.	11:55 p.m.	1.64	.07	.16	.29	.40	.51	.62								
Williston, N. Dak	15			0.68														.28			
Wilmington, N. C	29			0.57														.45			
Winnemucca, Nev	28			0.15														.13			
Wytheville, Va	23	5:42 p.m.	9:20 p.m.	1.17	5:42 p.m.	5:53 p.m.	.00	.27	.58	.62											
Yankton, S. Dak	25–26	9:15 p.m.	12:45 a.m.	1.06	9:46 p.m.	10:21 p.m.	.06	.11	.17	.27	35.	.41	.47	.55							
Yellowstone Park, Wyo	21			0.40														(*)			

(*) Self-register not working. [1] Apr. 30.

TABLE III.—*Data furnished by the Canadian Meteorological Service, May, 1915.*

Stations.	Pressure. Station, reduced to mean of 24 hours.	Pressure. Sea-level, reduced to mean of 24 hours.	Pressure. Departure from normal.	Temperature. Mean max.+mean min.÷2.	Temperature. Departure from normal.	Temperature. Mean maximum.	Temperature. Mean minimum.	Temperature. Highest.	Temperature. Lowest.	Precipitation. Total.	Precipitation. Departure from normal.	Precipitation. Total snowfall.
	Inches.	*Inches.*	*Inches.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	*Inches.*	*Inches.*	*Inches.*
St. Johns, N. F	29.52	29.66	−0.32	40.2	−2.7	45.9	34.1	64	30	5.27	+1.61	T.
Sydney, C. B. I	29.73	29.77	− .20	44.4	−0.8	53.8	35.0	70	26	1.62	−2.15	
Halifax, N. S	29.70	29.80	− .18	48.0	−0.4	56.9	39.1	72	31	6.80	+2.54	T.
Yarmouth, N. S	29.76	29.83	− .15	46.2	−1.4	53.0	39.4	65	34	3.48	−0.32	
Charlottetown, P. E. I	29.75	29.79	− .17	45.0	−1.9	52.6	37.5	64	31	4.01	+1.10	2.5
Chatham, N. B	29.81	29.83	− .12	46.6	−1.9	55.3	37.8	72	32	6.44	+3.23	7.5
Father Point, Que	29.81	29.83	− .10	43.4	−0.6	49.7	37.2	64	29	4.47	+1.89	0.1
Quebec, Que	29.53	29.84	− .10	49.9	0.0	59.8	40.0	77	32	3.40	+0.32	
Montreal, Que	29.66	29.87	− .07	52.3	−2.4	61.0	43.6	76	35	2.32	−0.63	
Stonecliffe, Ont	29.31	29.92	− .01	49.2	−3.1	62.1	36.2	79	26	1.04	−1.47	
Ottawa, Ont	29.64	29.96	+ .02	51.6	−3.3	61.6	41.6	75	33	2.38	−0.21	
Kingston, Ont	29.62	29.93	− .03	49.8	−3.1	58.0	41.7	72	30	1.83	−0.85	
Toronto, Ont	29.52	29.90	− .08	52.1	−1.1	61.7	42.6	74	33	1.60	−1.44	
White River, Ont	28.63	29.96	+ .01	43.3	−2.4	57.0	29.6	75	17	1.63	−0.32	0.5
Port Stanley, Ont	29.29	29.93	− .04	49.6	−3.5	58.4	40.8	69	30	3.04	−0.14	
Southampton, Ont	29.24			48.3	−2.4	58.2	38.4	76	28	1.19	−1.25	T.
Parry Sound, Ont	29.23	29.93	− .02	49.8	−1.3	60.8	38.9	74	26	0.95	−1.98	
Port Arthur, Ont	29.27	29.98	+ .02	47.5	+1.6	57.0	38.0	68	27	2.09	−0.06	
Winnipeg, Man	29.16	29.99	+ .03	52.8	+1.2	66.0	39.6	81	24	0.82	−1.46	1.1
Minnedosa, Man	28.17	29.98	+ .02	51.1	+2.7	64.3	37.9	80	24	1.71	+0.26	2.5
Qu'Appelle, Sask	27.68	29.91	− .03	50.6	+0.8	64.4	36.9	78	14	3.10	+1.45	
Medicine Hat, Alberta	27.59	29.86	− .03	56.5	+2.4	69.9	43.1	82	28	2.72	+1.41	
Swift Current, Sask	27.32	29.88	− .04	52.3	+1.6	64.8	39.7	78	22	4.29	+2.53	
Calgary, Alberta	26.31	29.82	− .06	49.6	+0.6	61.4	37.9	78	31	3.13	+1.36	
Banff, Alberta	25.32	29.88	0	46.4	−0.6	56.6	36.1	70	28	2.24	+0.20	1.1
Edmonton, Alberta	27.62	29.90	+ .02	52.2	+1.4	64.4	40.0	77	27	1.30	−0.25	
Prince Albert, Sask	28.38	29.93	− .02	51.0	+3.4	62.6	39.4	78	27	0.92	−0.34	
Battelford, Sask	28.22	29.95	+ .03	54.8	+3.8	68.9	40.7	80	30	1.61	−0.01	
Kamloops, B. C	28.62	29.90	+ .01	58.5	−0.6	70.1	46.9	85	37	2.28	+1.04	
Victoria, B. C	29.65	29.90	− .10	53.9	+1.4	60.4	47.5	72	42	1.26	−0.22	
Barkerville, B. C	25.51	29.77	− .07	47.0	+1.5	58.5	35.4	72	28	3.74	+1.22	5.7
Hamilton, Bermuda	29.88	30.04	− .02	69.6	+0.2	75.5	63.7	80	59	1.82	−2.84	

Chart I. Hydrographs of Several Principal Rivers, May, 1915.

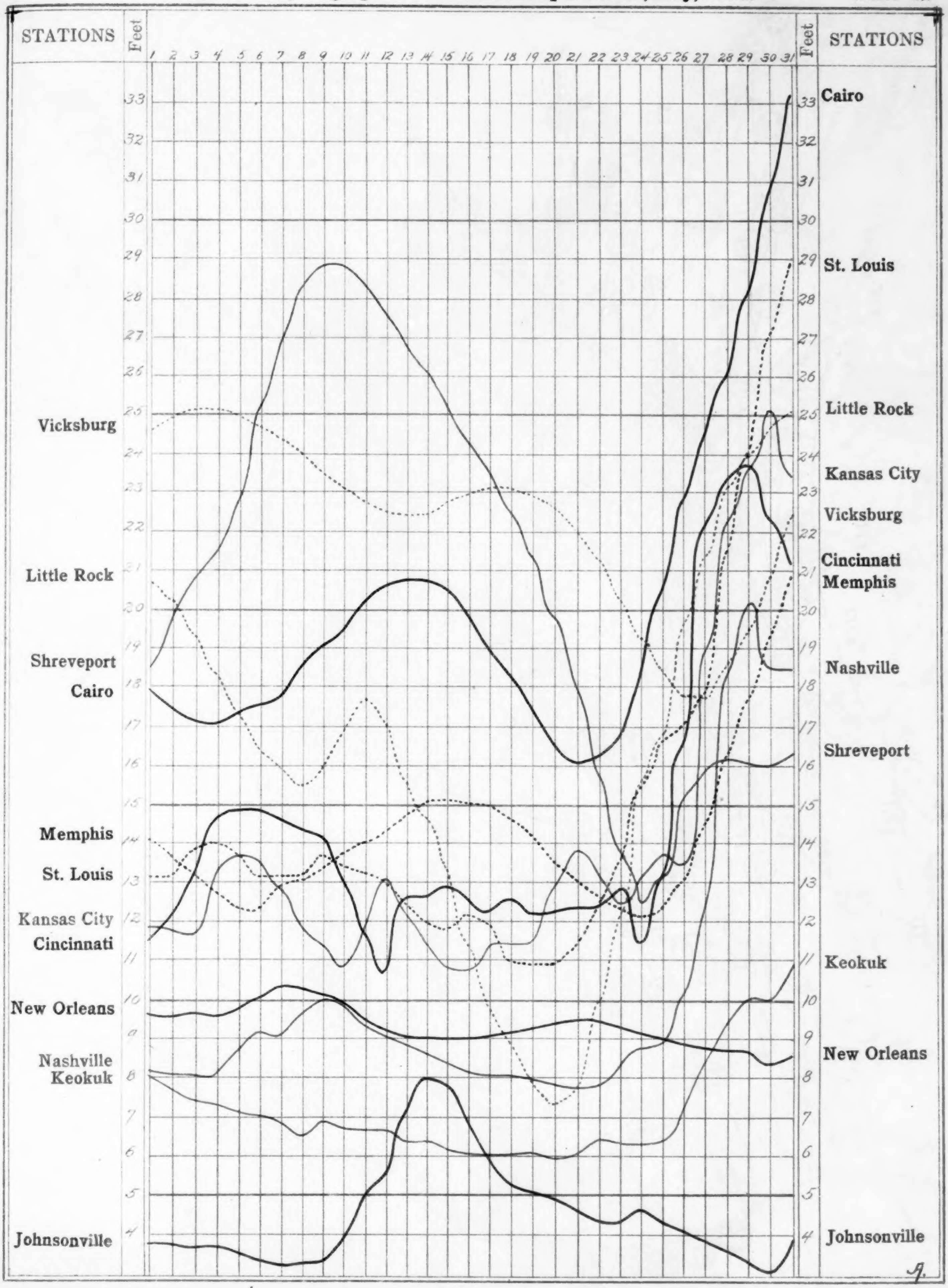

Chart II. Tracks of Centers of High Areas, May, 1915.

(Plotted by R. H. Weightman.)

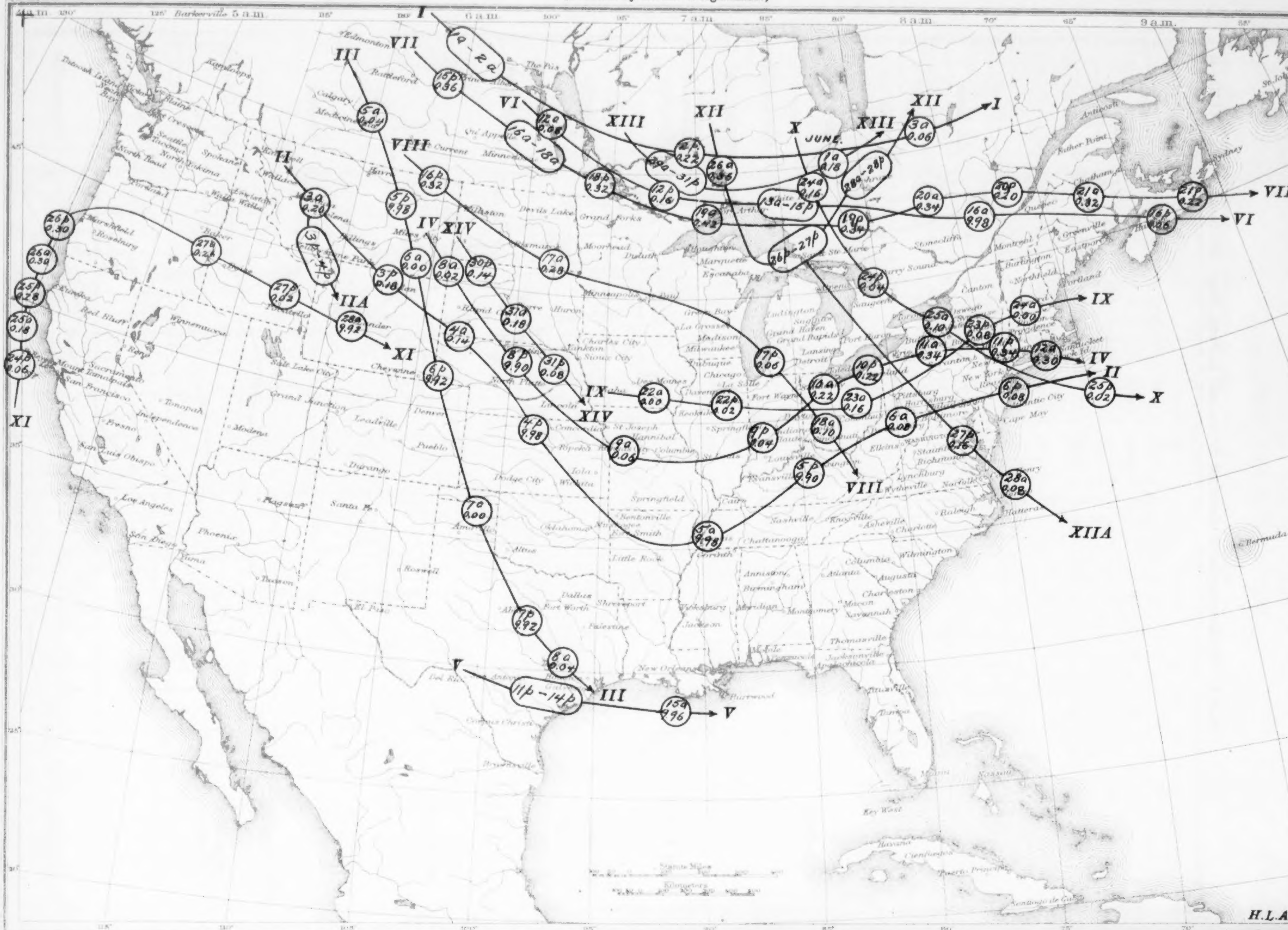

Chart III. Tracks of Centers of Low Areas, May, 1915.

Chart III. Tracks of Centers of Low Areas, May, 1915.
(Plotted by R. H. Weightman.)

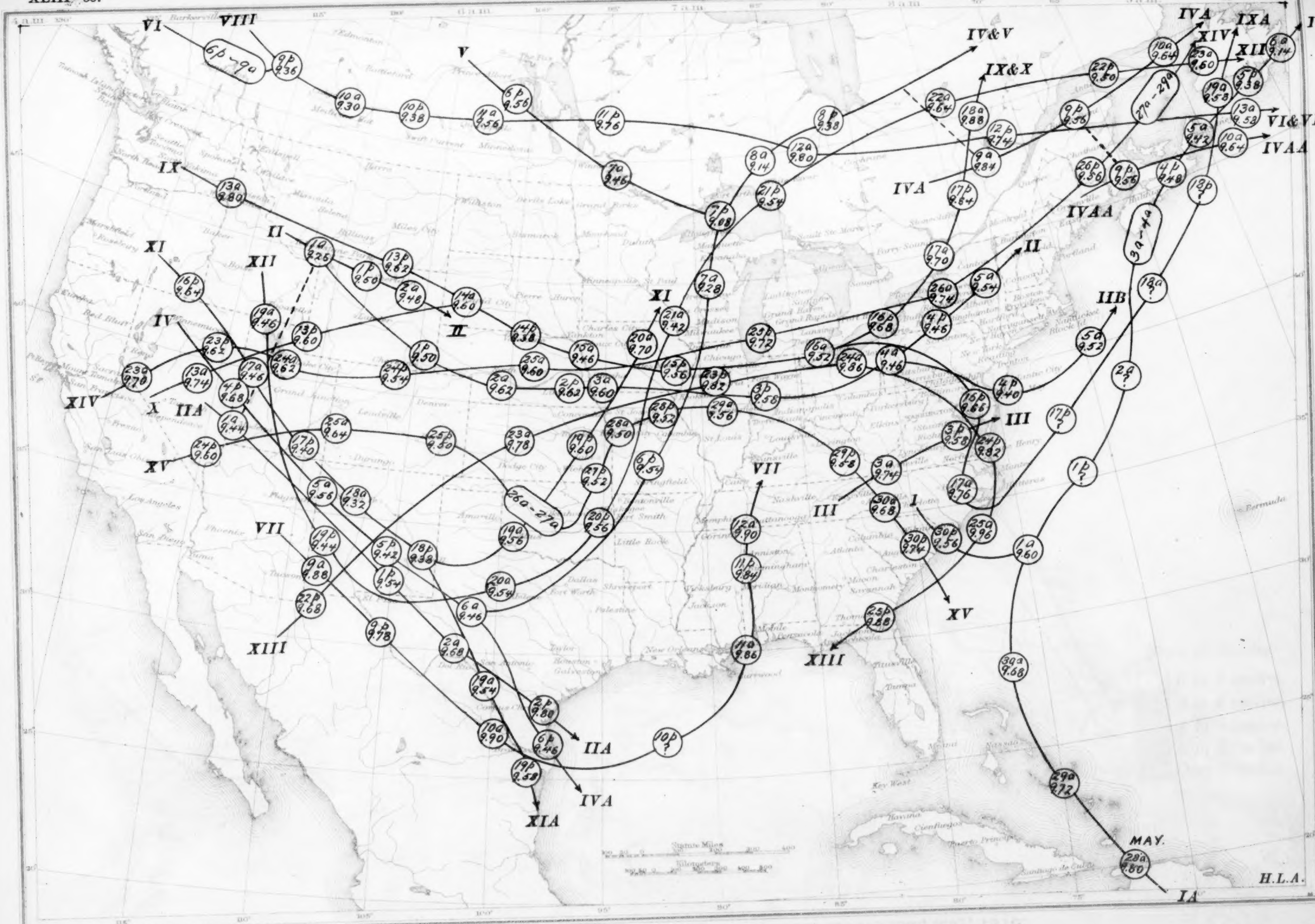

Chart IV. Departure (°F.) of the Mean Temperature from the Normal, May, 1915.

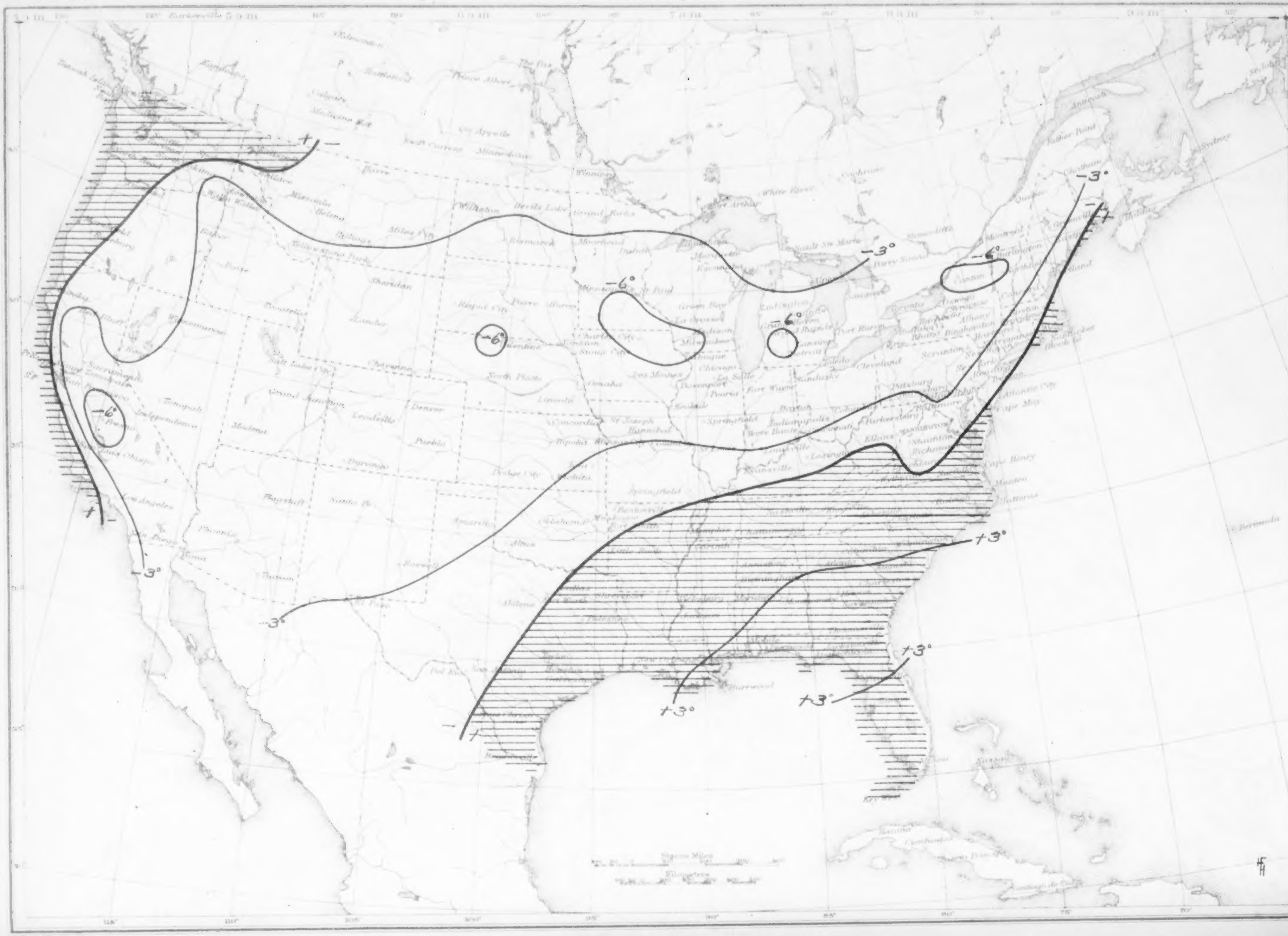

Chart V. Total Precipitation, Inches, May, 1915.

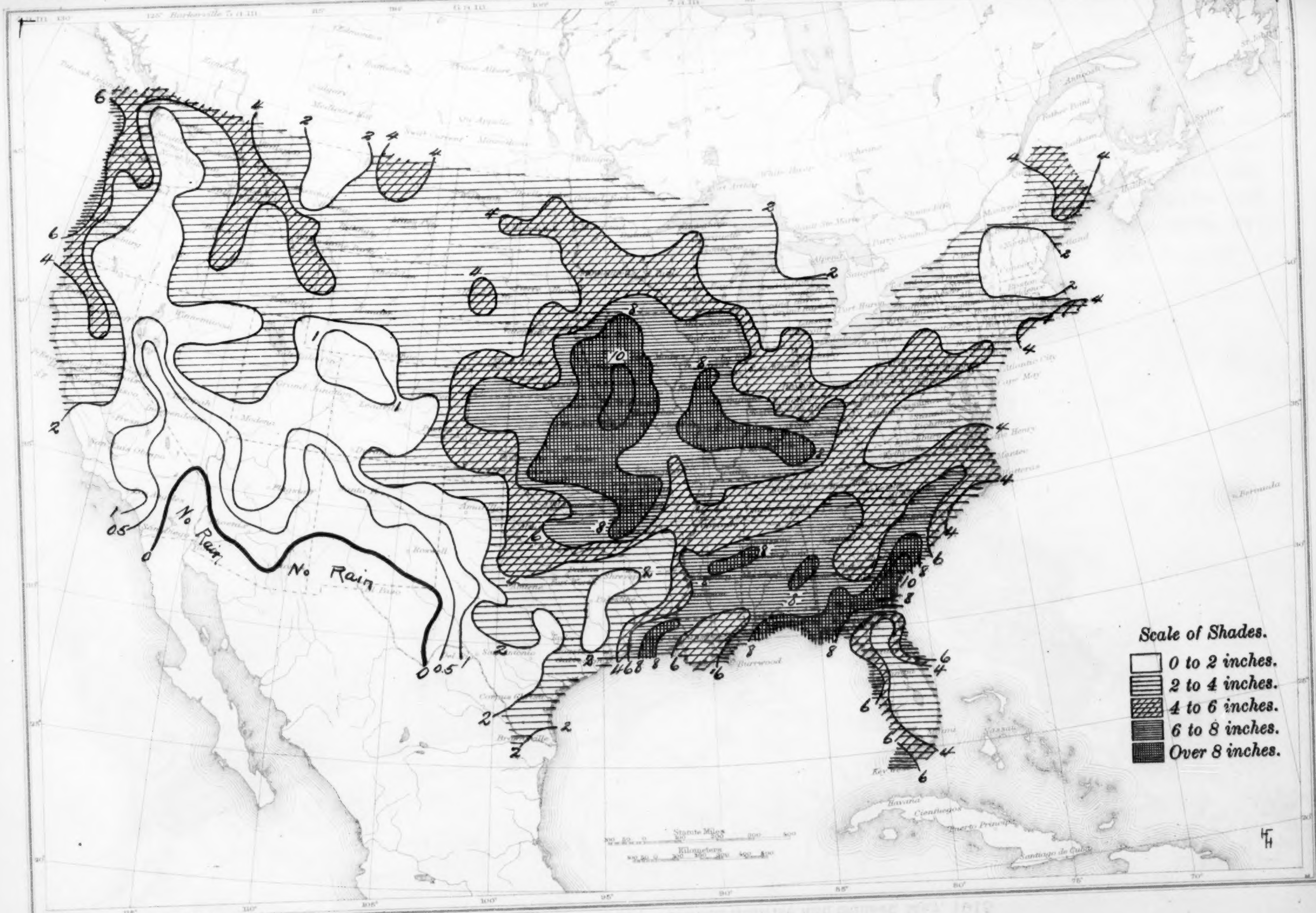

Chart VI. Percentage of Clear Sky between Sunrise and Sunset, May, 1915.

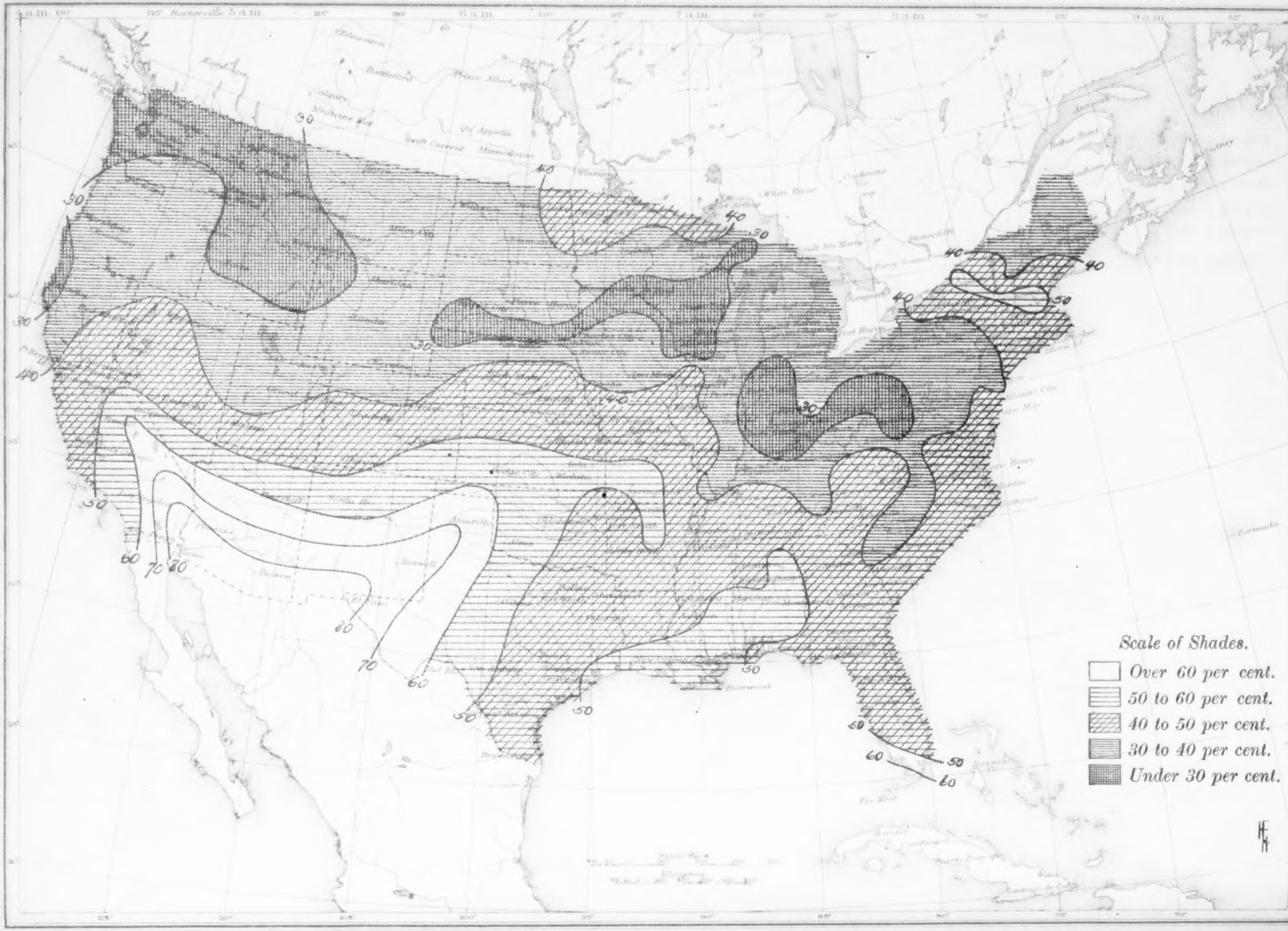

Chart VII. Isobars and Isotherms at Sea Level; Prevailing Winds, May, 1915.

Chart VII. Isobars and Isotherms at Sea Level; Prevailing Winds, May, 1915.

Chart VIII. Total Snowfall, Inches, May, 1915.